C. V. Walker Esq
with the Authors thanks and best regards

REPORTS BY THE JURIES.

Class X.

PHILOSOPHICAL INSTRUMENTS AND PROCESSES DEPENDING UPON THEIR USE.

J. GLAISHER, F.R.S., *Reporter*.

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Jury.

Sir David Brewster, F.R.S., *Chairman*, St. Andrews, Fifeshire, N.B.; Principal of the University, St. Andrews.
Professor Colladon, Switzerland.
E. B. Denison, 42 Queen Anne Street.
J. Glaisher, F.R.S., *Reporter*, 13 Dartmouth Terrace, Lewisham; Observer in Greenwich Observatory.
Sir John Herschel, Bart., F.R.S., 32 Harley Street; Master of the Mint.
Professor Hetsch, Denmark.
E. R. Leslie, R.A., United States; Artist.
L. Mathieu, France; Member of Bureau of Longitude, of Institute, and of Central Jury.
W. H. Miller, F.R.S., Scroope Terrace, Cambridge; Professor of Mineralogy.
Richard Potter, A.M., University College, London; Professor of Natural Philosophy.
Professor Schubarth, Zollverein; Professor of Chemistry and Natural Philosophy.
Baron Armand Seguier, France; Member of Institute, &c.

Associates.

J. S. Bowerbank, 3 Highbury Grove.
Rev. W. S. Kingsley, Sidney College, Cambridge; Fellow of Sidney College.
L. A. J. Quetelet, Belgium; Secretary to the Royal Academy at Brussels. (Juror in Class XXX.)
Lord Wrottesley, 34 St. James's Place.

The duties of the Jury upon Philosophical Instruments have been found to be very heavy, as indeed might be expected in a field so vast, including instruments relating to Astronomy, Optics, Light, Heat, Electricity, Magnetism, Acoustics, Meteorology, &c.; in fact, all relating to Physical Science, collected by a large number of exhibitors.

Astronomical instruments claim our first attention; the exhibitors of which, though few in number, have effected a most beneficial advance by the use of as few parts in their construction as possible: this is mainly observable in the British portion. The workmanship of those exhibited by Germany deserves the highest praise: the instruments are, however, few in number, and do not fully represent German art.

America claims particular notice by the application of electro-magnetism to the registration of astronomical observations, thus enabling the hand to do the work of the mind. This method has the further advantage of being able to record the observations taken at far-separated Observatories, the length of the wire used being immaterial: thus is established a means the best possible for the determination of the difference of longitude. Observatories so connected afford the means of performing the most delicate experiments dependent upon the appreciation of minute portions of time. This method has been recently used in America, for the determination of the wave-time of electrical currents; from which experiments it would seem that its velocity of propagation is much smaller than that determined by Wheatstone.*

Of nautical instruments, there are several exhibitors; but with the exception of those of America by Ericsson and St. John, there is but little novelty of construction. In surveying and levelling instruments, except some improvements observable in those exhibited by Austria, there is no novelty. In optics there are many exhibitors; and we remark the improvement of optical glass in England, France, and Switzerland, and that the construction of large discs of glass for telescopes, in England, promises to add considerable optical power, and thereby to the advancement of Astronomy, &c. Of microscopes the British are by far the best. In physical optics generally, France is pre-eminent, having exhibited a number of delicately-constructed instruments, none of the same kind being contributed by any other nation: she also excels in lenses and in prisms. There are many other classes of optical instruments, to be specified hereafter.

There are many photographic cameras, to the improvement of which much attention is at present being paid in both England and France. This leads us to the most remarkable discovery of modern times—the art of *photography*—and never before was so rich a collection of photographic pictures brought together, the products of England, France, Austria, and America.

Before going further, it would be well to inquire into the utility of the photographic process as regards its application to art and science, and indirectly to literature, by affording a faithful transcript of authentic papers and original documents, upon which subsequent literary and historical research must necessarily be greatly dependent. That photography is yet in its infancy there can be little doubt; and it is more than probable that its present application, which we believe to be well represented in the Exhibition, is no more its ultimatum than were the first applications of the telescope, shortly after the chance placing of two pieces of glass by Jansen's children had led to its invention. Who at that time could have predicted the important part that the instrument, based upon that discovery, was destined to play in the world of science? or have foreseen the excellence which it has since attained by successive improvements even now making, and of which the Exhibition affords ample proof.

Viewing photography in connection with art, it may at first appear as if a vast and powerful rival had risen up against and was destined to depress her in exact proportion to the superiority of the operations of nature over those of man. In its success, we perhaps expect to behold a transcript of objects and compositions more elaborate and more truthful than any the greatest genius could ever hope to achieve: united to this, and in addition to the rich Vandyke browns and Claude Lorraine tints of many of the works now before us, by the agency of chemicals whose existence is yet unknown, we may see foreshadowed a perfection of colouring as yet never imagined. By improvements in the camera and the daily increasing practical knowledge of experimenters, we may expect to behold compo-

* See Gould's Astronomical Journal, Vol. i., Nos. 2, 7, and 14.

sitions, embodying a degree of reality otherwise beyond our power of attainment. The truthful delineation of the various and just relations of the architectural edifice, the groups of figures at its base, the middle distance blended into the horizon by gradations so fine and truthful, as to defy the utmost efforts on our part to surpass or even equal, are indications only of that which will ultimately be achieved by the photographist, rich in experience and knowledge of the processes of photographic art.

But this is a superficial and imperfect view of the case, not as regards the ultimate perfection of photography itself, but as concerning its influence upon art. With art, doubtless, its future destiny will be closely linked; but so far from becoming a rival, it will prove a most useful auxiliary, and a means by which the artist of merit may rise higher in reputation and eminence. By using photography as a means of replacing the purely mechanical parts of his labour, the work of the artist may be much lightened; and as by speedy transit from place to place man's life is virtually lengthened, so by relieving his path from that part of his labour, which involves an expenditure of time disproportionate to the end attained, one great obstacle to the achievement of success is removed. Never need the artist fear that the employment of its services in conjunction with his pencil, or his adaptation of it in any way to his art, will ever derogate from that art, or render him a servile copyist; we may rather predict that each improvement in photography will tend to place both the painter's and the sculptor's art on a firmer and surer basis. It is likely that time will show that this beautiful compound of art and science will essentially cast its weight into the balance of art, and in future render itself more and more inseparable from and essential to her interests.

That photography will have a great tendency to depress mediocrity, we may safely predict; that from the date of the general application of photography to the illustration of scenes daily passing around us, will commence a new era in pictorial representation; that it will greatly enrich us with authentic records of works, that would otherwise pass away without a single detaining effort from the hand of the artist, owing to their being of too transient a nature to admit of the accuracy and detail necessary to give it value in future ages, is attested by the various and excellent representations which we now possess of the Exhibition building itself, in all its stages, by the faithful and well-executed photographic pictures of MM. Martens, Claudet, &c. Great is its usefulness as applied to transitory scenes of the above kind, and incalculable will be the advantage posterity is sure to reap from the ever-increasing collection of such truly graphic representations, and great service, too, will the plain and truthful records of photography afford to the historian of future ages. As applied to the illustration of works of the present day, it may be of twofold service. By its application may be superseded the works of individuals, in whose hands illustration is rendered a mere trade, and the directing of whose exertions into another channel would be a means of removing many obstructions which hinder the advance of art. At the same time, the many books we possess for the education of the young, which are crowded with illustrations unfortunately but too well calculated to produce most erroneous impressions, would at once give way before the truthful representations of photography, which, by diffusing a more correct taste, would give essential aid to art herself.

Let us now view photography in its applications to science. A process by which transient actions are rendered permanent, and which enables nature to do her own work, or in other words which causes facts permanently to record themselves, —is too well fitted for the purposes of science to be long overlooked; but the difficulties to be overcome in its application, have been, and still are great, and the results proportionably few in number: we consider, however, that the commencement of a systematic application of the photographic process to the purposes of astronomy is indicated by the daguerreotype of the moon by Mr. Whipple; and great indeed will be the benefit conferred upon astronomical science, when we obtain permanent representations of the celestial bodies and their relative positions, transmitted through the agency of light.* Another illustration is afforded by the self-registering apparatus of Mr. Brooke, in which nature is made to perform the operations of a corps of observers, by an application of what must be considered a few only of the first principles of photography. That its application in causing instruments which are continuous and delicate in their action, to register their own work, must be attended with advantages—is evident to every reflecting mind; and points to some of the further advantages science is likely to derive from the ultimate perfection of the photographic processes.

As applied to the preservation of documentary collections, and thus indirectly to the purposes of literature, its use is too important to be passed over in silence. How often has the historian in his search after authentic papers, and original documents, found them only to regret, that to posterity he must be the chronicler of events, the vouchers for which will have perished by the unavoidable ravages of time, or, as in too many cases, by supine neglect. To make use of the means afforded by photography to procure fac-similes of these, is a duty we owe, not only to posterity, but to our forefathers. Again—as applied to valuable documents of the present day, either testamentary or legislative, how important to secure photographic transcripts of these, which, being of indisputable authority, shall be also perfectly unavailable for any purpose other than that intended.

Let us now turn our attention to the collection before us, in which for daguerreotype portraits America stands prominently forward. France first in order of merit for calotypes, or sun-pictures. England possessing a distinct character of her own, and presenting illustrations of nearly all the processes which have as yet been adopted. America stands alone for stern development of character: her works, with few exceptions, reject all accessories, present a faithful transcript of the subject, and yield to none in excellence of execution. France, in her daguerreotypes, of which she has but few, offers bright sunny representations; their effect rather injured than improved by too great masses of sunlight; but in her calotypes she stands unrivalled, and all but rejecting the processes of Daguerre, has concentrated all her energies in the further development of those of Talbot and his school.

Eminent amidst the exhibitors of calotypes is M. MARTENS, whose works we may say with certainty have never been surpassed; their colour, arrangement, and perfect finish, call forth the highest admiration: his success is not confined to

* The success of this application of photography must be dependent, to a considerable extent, on the object-glass of the telescope. The Report on Telescopes will show whether the improvements in this department of optics are commensurate with the requirements of photographic representations of this class.

one class of delineation in particular, the individual works comprising his collection, being nearly all of equal merit.

On turning to the photography exhibited by the United Kingdom, we find Claudet leading the way, and adding to the many improvements introduced by him into the various processes of the art by presenting the image *direct* instead of *inverted:* this is the distinguishing feature of his collection, and is the result of patient and untiring research in that class of investigation peculiar to himself.

Ross and Thomson of Edinburgh are fairly entitled to attentive consideration from their successful use of the albuminized glass, which they prepare by a process different to that adopted by M. Niepce, its originator, applying the albumen so as to insure its even distribution—upon which evenness the success of the picture is mainly dependent. The pictures in their collection, combine, with exceeding delicacy of execution, a richness of colour equal to that of Martens', but surpass him in the diversity of tints; the collection, besides embracing a long range of sepia tints and Vandyke browns, includes a small picture the colour of which is *blue*, and as this is a hitherto unprecedented result, we are led to give it weight, and will, in another place, describe the process by which it is produced. Some details connected with the methods adopted by Messrs. Ross and Thomson, and kindly furnished by them, are subjoined.

The process for producing negative Talbotypes, on glass, is as follows:—The whites of two eggs, being a quantity sufficient for coating a plate of glass 12 inches square, are placed in a bowl, and cleared from all opaque particles; ten drops of a saturated solution of iodide of potassium are added for each egg, and two-thirds of a wine-glass of water for both, the whole being then beaten up to a light froth and carefully covered up and left to regain its liquid state; the glass to be coated is well cleaned with a solution of pure water and soda, or potass, and rubbed quite dry with a silk rag. The mixture is then poured on as evenly as possible, and fastening a piece of wire to the opposite corners, the excess of albumen is poured off by turning the plate gently upside down; it is afterwards made to revolve before a clear fire, by a thread of worsted tied to the suspending wire: when the albumen begins to crack, the plate should be removed to a greater distance, and there suffered to remain until equally cracked all over. To render the plate so prepared fit for the camera, it is breathed upon, to give it a degree of softness and to cause it to absorb as much silver as possible; it is then dipped (the prepared side undermost) very gently in a bath of nitrate of silver, prepared in the proportion of 60 or 70 grains to an ounce of water, the plate being prevented from touching the bottom of the vessel by a piece of bent glass, or metal covered with wax. It is then washed in a large dish of clean water, by repeated dippings, care being taken to keep the water running in the same direction. The plate is then placed in the camera, and if the picture when taken, is to be immediately developed, a quantity of acetic acid is added.

The mode of developing the image is as follows:—a quantity of saturated gallic acid is poured on the plate, and spread evenly with soft cotton-wool, after which, when the picture has well appeared, a small quantity of gallic acid is mixed with the nitrate of silver solution, and spread over the glass, which gives the development strength, and renders it more rapid. At this stage of the operations, a solution of hyposulphate of soda (50 grains to an ounce of water) is poured over the picture, and carefully spread with clean cotton ; the process is then completed by pouring some water from a jug very gently over the surface.

The negative proof so obtained is transferred to paper by floating the latter on a solution of common salt (5 grains to an ounce of water) for a space of two minutes ; it is then pinned up to dry, and floated on a solution of nitrate of silver (70 grains to an ounce of water) for three minutes ; it is then dried in the dark, and afterwards placed with its prepared side to the prepared side of the glass negative, and screwed in the pressure-frame with a plate of glass below to insure its close contact. The pressure-frame should be surrounded with black boards to cut off the rays of light from the sides. To fix the impression, it should be first washed in cold water, then in hyposulphate of soda (100 grains to an ounce of water) for 15 minutes. It is then washed once in cold water, five or six times in boiling water, and finally suffered to remain an entire night in cold water, so as to remove entirely the remaining hyposulphate of soda, which would, in course of time, eat out the picture if allowed to remain.

The photograph so obtained is afterwards mounted upon card-board, and pressed on a warm plate of steel, to communicate a slight glaze, which may be considered an improvement to its appearance.

The process we have just detailed is good in many points, but defective chiefly in one—sensitiveness ; every effort to increase which has hitherto been attended with a softening of the albumen. This is a difficulty, but one which Messrs. Ross and Thomson will doubtless overcome.

The *positives* on *glass* are transferred and fixed in the usual manner (the albumen being mixed with salt instead of iodide of potassium), with the addition of pure plaster of Paris, which being mixed with the solution is poured on the face of the picture, and adhering to the albumen in a manner hermetically seals it, and thus effectually preserves it from injury.

This admirable system is, we believe, entirely due to Messrs. Ross and Thomson, whose collection of Talbotypes amply attests the superiority of their method ; and indeed, as is the case of Mr. BUCKLE, of M. MARTEN, or of any highly-successful photographist, it is but fair to infer that the superiority observable in their productions is due to their improvement of the processes which they have adopted.

Whether the followers of Talbot will ever obtain a pre-eminence over those of Daguerre, or *vice versâ*, is a question for time to solve ; at present the two systems appear in the British department of the Exhibition to be equally well represented ; the followers of each, with few exceptions, laying claim to some improvement or peculiarity of manipulation. For example, in addition to the cases already mentioned may be included those of MAYALL, who calls attention to his crayon daguerreotype, an invention of his own, and BEARD, whose *patent* enamelled process is one of the very few instances of a patent having been obtained for any improvement connected with this art. Great as is the satisfaction with which we regard the efforts made for perfecting the processes of Daguerre and Talbot, still greater is that with which we observe experimenters divulging the processes they have adopted : the hitherto all but total avoidance of patent enrolment must be considered a distinctive feature of this art, to which fact, doubtless, added to the ready divulging of improvements, is chiefly due the rapidity by which up to the present time its progress has been characterized. The publication of each new process opens a fresh field of philosophical inquiry, gives to man increased physical knowledge, and may work great changes in his moral destinies.

We cannot pass from the subject of photography without alluding to a loss recently experienced in the death of its founder, M. Daguerre, whilst the Jury were engaged in their duties, and we feel it due from us not to let his memory pass unnoticed. In him was lost one of the lights of the age.

We now proceed to electric telegraphs, of which a great variety are placed in the Exhibition; many of them are remarkable for novelty of construction, and for important improvements. In the section devoted to their description we shall speak of them at some length.

When Oerter, in 1820, linked together the sciences of electricity and magnetism, great hopes were entertained of the application of electro-magnetism to the movement of machines; and as in the Exhibition there are several arrangements for obtaining motive power in this way, we are far from despairing of its successful application to mechanical motion.*

When Faraday obtained the converse of electro-magnetism, by induced electricity from magnets in motion, he originated magneto-electricity, and it is possible that its successful application to the purposes of the electric telegraph will supersede the use of galvanic electricity. The experiments which were made before us with the magneto-electric telegraph were satisfactory.

The application of voltaic action, by coating the inferior metals with the superior, is shown in the Exhibition in some beautiful electrotypes and intaglios; also in a recent and highly-important application by T. H. Henry, Esq., F.R.S., as shown in the coating beams of balances with platinum and palladium.

Chemistry and chemical apparatus need not detain us long—the Exhibition presenting little (in Class X.) that is new, excepting the application of the former to the extinguishing of fire by Mr. Phillips, who has successfully brought this element under our immediate control by the agency of carbonic-acid gas, nitrogen, and aqueous vapour. His contrivance, by which these agents are evolved, differs materially in its action from that of water, which simply cools the burning substance to a temperature too low for the existence of inflammable gas, but does not at all interfere with the current of fresh air, every accession of which is attended with a fresh increase of combustion. The chemical agents constituting the gaseous vapour generated by this machine, on the contrary, are highly inimical to fire, chiefly from the fact of their entirely preventing all access of pure air to the burning mass. There is another patented application of this kind, but we are ignorant of its details and application.

The planimeters exhibited claim some attention, there being several ingenious machines of this kind adapted to the determination of areas of plane surfaces by mechanical means.

There are several exhibitors of air-pumps, who have exercised much ingenuity.

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* See Jacobi's papers in Taylor's Scientific Memoirs; and also Lens on Electro-Magnetism in the same work.

There are various machines for standard measures of length exhibited, two of which are extremely beautiful.

Calculating machines claim some attention as a mechanical power by which the hand is made to do the work of the mind; and operose and long calculations, requiring much strained attention, are performed by turning a handle. Two such machines are shown, which performed well and accurately.

We cannot help recording how clearly the injurious effects of patent enrolments on science were shown in the course of our labours: many of the ingenious contrivances exhibited proved to be merely variations, for the avoidance of the infringement of patents. In many cases the subjects patented were of a very trifling nature, but still their effect was to shut up the path in that direction from further improvement. The great advance of photography, previously alluded to, and the perfection of the microscope, are chiefly due to the avoidance of patents in connection with their improvements.

It was found that the instruments exhibited were, for the most part, collected without any concurrence on the part of the exhibitors, for the representation of the state of science in their respective countries, and that therefore it was useless to examine the instruments of each country separately. In the following Report we have, therefore, classified the instruments according to their use, including the contributions of all nations.

It is but right to say that some instruments inserted in the Catalogue have not been found, and that in other cases neither the exhibitor nor any explanation of the instrument were to be met with.

We now proceed to desbribe the several instruments in each Class.

Astronomical Instruments.

It is to be lamented that this department of the Exhibition contains results of the labours of but few individuals; and of large instruments, with the exception of the great equatorial by Ross, there is not one. This circumstance, how much soever a matter of regret, is not one of surprise;—the risk of injury and difficulty of carriage being in some cases almost insurmountable, and the same obstacles existing in full force, with regard to the exhibition of the large class of instruments termed portable. When we consider that, in addition to the above obstacles, the risk of transmission and danger attendant upon removal must necessarily be great, and the involved exposure highly hazardous, the scarcity of instruments in the British, and more particularly in the Foreign Department, will be sufficiently accounted for.

But in those instruments which are exhibited, it is highly satisfactory to find the greater part of them characterized by exquisite workmanship, and a steady advance in their construction.

In Mr. Ross's great equatorial, it will be seen that he has followed the example of the Astronomer Royal, by having every part of the instrument cast in as few pieces as possible, and has thus avoided all unnecessary screw connections. The casting of this instrument, by Messrs. Ransomes and May, is a fine piece of work. The same principle of casting has been adopted by Mr. Simms, who has avoided various screw connections in the construction of his instruments.

It is most gratifying to perceive that, small as is the number of astronomical instruments, the credit reflected upon the artists is very great: thus, the instruments exhibited by Mr. Simms possess points of high interest, viz., the conversion of the axis of the transit into a telescope; the modes of illuminating the wires and field of telescopes; the application of the principle of vertical collimation to the altitude and azimuth instrument by piercing the vertical axis; the adapting the axis of an equatorial to the application of a level, &c.,—all of which must be looked upon as improvements, and cannot fail to be of great service for the purposes of observation.

In the German instruments of Merz and Ertel there is exquisite workmanship, well maintaining the celebrated names of the makers of the Poulkova instruments. The divisions of the Ertel instrument are beautiful; but works of this kind performed by hand-dividing are operose and distressing.

The practice of hand-dividing in this country is now almost superseded by machinery. Mr. Simms' instruments, for the most part, have been so divided. The advantages of this method cannot be better shown than in the comparison of the time occupied by the division of one of the instruments in the Exhibition, the far-famed Westbury circle, and the time now occupied in performing the same piece of work.

The graduation of the two circles of the Westbury instrument occupied Mr. Simms, as he has informed us, nearly twelve weeks of six days each week, and on an average of eight hours every day. The work was performed by lamp-light, in a room otherwise completely darkened; and although practice enabled him, on subsequent occasions, to accomplish similar pieces of work in considerably less time, yet he always found it to be an exceedingly anxious and oppressive work. By the means of Mr. Simms' self-acting dividing engine,* the actual graduation is effected in five hours, to which length of time a period of about five hours is to be added, which is necessarily occupied in the arrangement of the instrument upon the engine preparatory to cutting the divisions. Thus the same work is done within ten hours which formerly occupied from five to six weeks, not to mention the saving of wear and tear upon the constitution of the operator. The divisions are found to be fully as accurate as those cut by the original process.†

In the American Department, Mr. Bond exhibits the electro-magnetic apparatus used successfully by the Americans, both for the purposes of geodesy and astronomy: this American invention promises to be a real improvement in practical astronomy, and will, in all probability, form a new era in astronomical observations.

Dollond (No. 145). A variation transit instrument. The horizontal circle is 12 inches in diameter, on which is fixed a smaller circle of 7 inches diameter; each

* This beautiful machine is described in the 15th volume of the Royal Astronomical Society.

† The dividing the eight-foot mural circle at Cambridge, which Mr. Simms graduated on its pier, occupied him several weeks: see the results of the examination of the divisions in the "Cambridge Observations," for 1833; see also the results of the examination of the alt-azimuth instrument at the Royal Observatory, "Greenwich Observations," 1847; and also the result of the examination of the divisions of the great transit circle lately erected at Greenwich, "Greenwich Observations" for 1851. Both these instruments were divided by Mr. Simms' self-acting dividing engine.

is divided to every 10′, and the larger circle has three verniers reading to every 10″. The telescopes are 14 inches focal length, and 1·3 inch aperture, with altitude circle and the regular transit series of spider-lines, supported upon four pillars fixed to the horizontal circle.

When the instrument is used for determining the actual or diurnal variation, there is a cover containing a lens, which is applied in front of the object glass of the telescope for reading off the divisions on the needles, of which there are two, 7 inches in length, together with various eye-pieces, &c. The instrument is supported on a strong tripod with adjusting screws.

SIMMS (No. 741). A transit instrument, intended for use either in the meridian or prime vertical. The telescope and axis are of the form usually employed for this class of instrument, viz., two stout cones are connected by a sphere into which the cylindrical tubes of the telescope are screwed; the pivots are of hard bell-metal, and are both perforated.

The object-glass has an aperture of 2¾ inches, and a focal length of 42 inches; the diaphragm is furnished with seven vertical and two horizontal spider-lines. There is another vertical spider-line carried by a micrometer screw, and which can be moved completely across the field, so that the distance of an object from any one of the fixed lines may be measured by its means. The lines are adjusted to the focus of the object-glass by a milled head near the eye-end, and another milled head is placed near the axis for the purpose of regulating the intensity of the illumination of the field of view.

The axis of the instrument is converted into a telescope, by having an object-glass fitted into one of the pivots, and a sliding tube carrying an adjustable cross of delicate spider-lines with a positive eye-piece in the other.

The adjustment of this axis telescope is effected by a small collimator placed in a line with the axis (unless a distinct mark can be seen through it), and then turning the axis round, and moving the proper screws until the intersection of the lines remain stationary upon the mark, or collimator-cross, during an entire revolution. If the principal telescope be adjusted to the meridian, the mark seen through the axis will be 90° distant in azimuth, and by its means the instrument can immediately be placed in the prime vertical, for the determination of the latitude by observation of stars near the zenith. By this invention the form of the pivots may be examined, for if they be not circular, the error will be shown when the cross is being adjusted. The azimuthal adjustment is provided with a micrometer head, showing seconds of arc, so that when the deviation is of known amount, the instrument may at once be placed exactly in the meridian. To take a complete observation of a star in the prime vertical, it is necessary to reverse the instrument, quickly and delicately, for a slight concussion might disturb the adjustments, and consequently vitiate the observation. For this purpose a reversing frame has been contrived and fitted to the base of the cast-iron stand or support upon which the instrument is placed. It consists of a strong screw having square threads, the circumference of which fits into a cylindrical hole bored through the centre of the stand, and is prevented from turning round by a key which fits into a groove cut longitudinally throughout the length of the screw. The screw is raised or depressed by a pair of bevelled wheels, one of which fits upon the screw, and the other is worked by a winch handle.

Above the screw a stage is fixed, and upon this two conical pillars are erected, having a fork covered with vulcanized India-rubber upon the top of each of them. Upon turning the winch, the screw is raised, and the forks are brought into contact with the transit axis, and by continuing the motion, the instrument is lifted out of its Y bearings. The frame with the instrument is then, by means of stops, which are attached to the stand, to be turned 180° in azimuth, and then by reversing the motion of the winch, lowered again into its bearings. Two setting circles of 4 inches diameter, and divided to one minute of arc, are attached to the eye-end of the telescope, both of which, previously to an observation, should be set to the zenith distance of the star, in order that no time be lost after reversing the axis, in again directing the telescope to the object.

The stage is forced upwards by means of four spiral springs, which rest upon the base of the stand: these are sufficiently strong to support the whole weight of the instrument when lifted, so that the friction upon the moving parts is very inconsiderable.

The eye-pieces with this instrument are six in number, namely, five direct magnifying 40, 53, 86, 120, and 140 times, and for zenith observations a diagonal eye-piece, magnifying 90 times.

Mr. Simms also exhibits a diagonal transit instrument of the form used by Reichenbach in his altitude and azimuth instruments. The object-glass is 1·7 inch in diameter, and has a focal length of 18 inches, with magnifying powers of 25 and 45 times. The circle, which is intended for a finder, is 6 inches in diameter, is graduated to show by opposite verniers to one minute of arc; a spirit lever is attached to the index of the circle, and there is also a sensitive spirit-level for the rectification of the axis. The whole is mounted upon a light cast-iron stand, and is suitable for fixing at a chamber window. In this construction, as is well known, the rays which pass through the object-glass, do not proceed directly to a focus, but are reflected by a prism, or speculum, within the axis, and form an image within one of the pivots, which is perforated, and in which the diaphragm and eye-piece are placed.

Up to the time of Mr. Simms' adopting this mode, no method for the illumination of the field of such an instrument had been devised, except the old one of placing a reflector in front of the object-glass, and throwing light upon it by means of a lamp or candle, in a distant part of the room in which the instrument was fixed. There are several objections to this method—first, the difficulty of throwing light at all upon the reflector under such circumstances; secondly, the trouble of having to readjust it when the direction of the telescope is changed; and thirdly, part of the object-glass itself is cut off by the reflector being placed in front of it. Mr. Simms has very ingeniously overcome these difficulties by lighting up the field of such an instrument, through the opposite pivot to that in which the diaphragm is placed, which obviates all these objections, and effects the object as easily in this case as in that of an ordinary transit instrument: the detailed means of doing this is as follows:—

The back pivot being perforated, has a small convex lens set within it, and a large convex lens of suitable focal length is fixed within the axis, at the back of the reflector, and its diameter is such that one or more segments near the edges (very small segments are sufficient), project beyond the edge of the reflector, and a lamp is placed at the back, with its light directed through the pivot. The action of the lens within the pivot condenses the light, which, after crossing, diverges upon the large lens at the back of the reflector, the open segments of which again condense it upon the field of view, where it produces a full and abundant illumination, which remains unchanged by any variation in the direction of the telescope.

GERARD (No. 109) has exhibited a portable or field transit instrument.

The instrument consists of two mirrors, so fixed as to measure an angle of 90 degrees. In use, two stations are selected, the one about 100 yards east or west of the other, and on the same level. A mark resembling a target with equidistant concentric circles, is set up at one of the stations, the instrument taken to the other, and so placed as to have the mark in the middle of the field. The telescope is then turned on its own axis till the sun or star is seen by reflection, which will be a few minutes before it passes the meridian. The times of its passing the different circles in succession should be noted. Another set of similar observations should be made at the second station, the mark being set up at the first. The time of the meridian passage will be the mean of all the times at both stations.

DOLLOND (No. 145) has exhibited an altitude instrument, with two circles of 2 feet diameter divided on silver to every five minutes, each circle reading off to seconds by means of two micrometer microscopes attached to the cones which support the instrument. Two small circles are fixed towards the eye end of the telescope, each of which reads off the minutes by verniers, with levels for setting the instrument in altitude. The telescope is of 2¾ inches aperture and 32 inches focal length, and is fixed between the two large circles. There are five vertical and three horizontal spirit levels in focus of the object glass, also various eye-pieces, &c.

The instrument is supported in Ys fixed on the top of two strong cones, which rest on a circular metal base, with differential screws for levelling. The usual method of illuminating the webs through the axis of the instrument is adopted. There are also two fine spider-lines reading to seconds.

Mr. Dollond also exhibits a double altitude instrument for observing by reflection and direct vision.* The altitude circles are 1 foot in diameter, divided to 20′, and are read off by micrometer microscopes showing seconds. Each circle has a telescope of 15 inches focus and 1·3 inch aperture attached to it, and there are two small circles, read by verniers, for setting the instrument in altitude.

The azimuth circle is 1 foot in diameter, and reads off by verniers to every 10″, having a telescope fixed underneath as a check upon the instrument when taking horizontal angles. The axes of the circles are perforated in the usual manner for illuminating the spider-lines. The instrument is furnished with fine spirit levels, eye-pieces, &c.

SIMMS (No. 741). A transit circle, the telescope of which has a focal length of 4 feet, and an aperture of 3·25 inches, furnished with a micrometer in the eye-piece, and magnifying powers of 63, 102, 130, and 165 times. The circle is 2 feet in diameter; it was cast in one piece of bell-metal. It was divided by Mr. Simms'

* See "Astronomical Society's Papers," Nov. 24th, 1823.

self-acting engine into spaces of 5′ of arc, and subdivided into single seconds by micrometers, of which there are two, fixed to the stone piers which support the instrument.

In addition to the finer graduations, there is another strong circle of divisions, which are cut upon the bell-metal, and numbered to four times 90, showing either altitude or depression. These divisions are read by a pointer, and they serve to direct the telescope to the object, whether it be seen by direct vision or by reflection.

The Y supports are fixed upon the stone piers. One of the Ys has a vertical adjustment for levelling the axis, which is performed by means of a striding level, and the other has an adjustment in azimuth for adjustment to the meridian. There is also a lever counterpoise fixed to that end of the axis near to which the circle is fixed for the purpose of equalizing the pressure of the pivots upon their respective supports. The instrument is furnished with an embracing clamp, or one which lays hold of the axis, to distinguish it from that kind which bites at the circumference, and also with a tangent screw, which exerts no lifting power, and has, therefore, no tendency to disturb the meridian position of the telescope.

The arrangement for the illumination of the wires is peculiar, and is the invention of the Astronomer Royal; but it was greatly facilitated by adoption of the peculiar method of graduating the light in the field of view, which had been practically introduced by Mr. Simms.

The illuminator, which is, as usual, placed near the centre of the transit axis, and receives the light through one of the pivots, turns upon an axis in order to change its angle of inclination with respect to the eye-piece. By this change of inclination the quantity of illumination is regulated; and if the plane of the reflector be placed perpendicular to the axis of the telescope, no light whatever will be reflected from it. Upon the reflector one or more prisms are so placed to receive the light from the lamp when the reflector is in darkness. These prisms reflect the light when the reflector is in the position above mentioned, but at no other time, to other prisms, which are fixed in the eye-end of the telescope, near to the diaphragm; and by these last prisms the light is thrown obliquely upon the spider-lines, and produces the effect of illuminating the wires on a dark field. To the edge of the reflector a wire is attached, which terminates in a small knob, or handle near to the eye-piece, and, therefore, near the observer's hand. The only operation required in passing from one state of illumination to another, with all the intermediate gradations, is either to draw out or to push in a knob or handle through a space of one or two inches.

By these arrangements power is given to the observer to regulate the quantity of light in the field of the telescope, from the faintest gleam, by which the wires are just made visible, to the full illumination, and also to change instantaneously, as circumstances require, a bright field and dark lines to a dark field and bright lines. This change has hitherto been effected by the employment of two lamps, one placed near the perforated pivot to give the ordinary illuminated field, and the other to apply occasionally at the eye end of the telescope, very nearly in the plane of the diaphragm, so that the light passing through a slit obliquely across the field of view, illuminates the lines which intercept its passage, leaving the surrounding field in darkness. It is clear that the change from one kind of illumination to the other with these arrangements, requires some considerable time, and the hanging a lamp on the eye-end of a telescope of such an instrument as a transit circle is exceedingly objectionable. By the new invention one immoveable lamp either illuminates the field or the wires, and the same lamp, at the same time, also illuminates the graduated circle by means of prisms attached to the micrometer microscopes.

This instrument has also another improvement, which was suggested by Mr. W. Simms, jun., since the erection of the transit circle at the Royal Observatory, Greenwich. It is by the perforation of a hole, about one inch and a half in diameter, through the centre cube of the axis, at right angles to the axis of the telescope, in order that a north and south collimator may look into each other without lifting the instrument from the Y bearings, and by this means very much simplifying the act of adjusting tho line of collimation.

Ross (No. 254) exhibits a large equatorial.

The focal length of the telescope is 18 feet, and the aperture is 11½ inches. The diameter of the hour-circle is 2 feet 3 inches, and that of the declination circle is 2 feet 8 inches.

The instrument is supported on a round cast-iron pillar 10 feet 9 inches in height, 2 feet 3 inches in diameter at the bottom, gradually decreasing to 1 foot at the top. It is formed of two portions, fastened together at the height of 4 feet 6 inches from the bottom of the base, by eight screw-bolts and nuts, passing through flanges, 3 inches in. width, from the shaft of the column. This joint affords the means of an approximate meridian adjustment. The base of the pillar is 9 feet in diameter.

The polar axis is of cast iron, 6 inches in diameter, and 5 feet in length; it is connected to the declination axis by a flange of 18 inches in diameter. The length of the inner male declination axis is 3 feet 6 inches between its bearings; and the outer or hollow axis is 7 inches in diameter. Both are of cast iron. The inner axis and its flange form one casting with the central hollow cylinder, to the flanges of which the corresponding gun-metal flanges of the telescope are bolted. The tube is of copper.

The fitting bearings of the declination axis are cylindrical, and the axis is secured by a steel collar 4 inches in length, fastened by cross pins to the male centre at the end to which the circle is fixed. In the inner axis there is a counter-sunk cavity to receive this collar, and a second counter-sunk cavity, of large diameter, to receive a steel plate, which is fastened against the end of the steel collar by eight steel screws. By this means the end shake of the axis is adjusted.

The declination circle is of gun-metal, and is regulated by an endless screw, having an eccentric lever attached to a dovetail slide for gearing, and a pair of bevelled wheels at either end for Hooks' joint adjusting rods. There are, also, two other radial arms, with clamp screws, for securely fixing the telescope to the circle.

The upper part of the polar axis fits into a coupling block, having a hemispheric bottom: this is supported by an angular projection from the top of the pillar having a corresponding nearly hemispherical cavity, and the whole is boun together by bolts and nuts, having spherical faces, which bear in corresponding cavities in their washers; the bolts pass freely through the holes.

The lower end of the polar axis is a hemisphere of hardened steel, bearing in a hardened steel die, surrounded by an oil-cup, which is attached to dovetail slides having motions in rectangular directions, which are supported by a very strong bracket, projecting from the main column, and are applicable to the final adjustment of the polar axis.

The hour circle is moved by a weight and train of wheels, regulated by a Siemen's governor, the ball being suspended by four springs.

This instrument reflects high credit on its maker; it is distinguished by solidity of structure, good mechanism, and distribution of strength.

Also, an astronomical telescope of $3\frac{3}{8}$ inches in diameter, 42 inches focal length, mounted equatorially. This telescope, on examination, was found to be a very superior instrument, and is the best in the Exhibition for its size.

Also, an astronomical telescope $2\frac{1}{2}$ inches in diameter, and 30 inches focal length, mounted on a pillar-and-claw stand.

Simms (No. 741), an equatorial, generally of the Frauenhofer form, with the polar axis elevated for latitude 25°, furnished with a clock motion for counteracting the effect of the earth's rotation. The focal length of the telescope is 7 feet, and its aperture is 4·9 inches: it is furnished with illuminating apparatus, a set of negative eye-pieces, magnifying from 60 to 450 times; a parallel line position micrometer with position circle, reading to one minute, and a transit eye-piece, the use of which is to facilitate the general adjustment of the instrument, and also for making observations for time, in the absence of a transit instrument.

The hour circle is 18 inches in diameter, and is read to one second of time by opposite verniers. The edge of this circle is ratched to fit the teeth of a screw, which is in connection with the clock before mentioned.

The declination circle is 18 inches in diameter, and is read by opposite verniers to 5″ of arc. The slow motion is by an ordinary clamp and tangent screen.

The action of the clock is under the government of a rotatory pendulum, similar to the governor upon a steam-engine.

The only peculiarity in this instrument is n the declination axis, which is not covered up, but open, and exposed between its two supports. The open part is turned cylindrical, and can be set horizontal by a striding level, similar to that of a transit instrument. This construction has several advantages over that in common use; it simplifies the adjustment and the rectification to the meridian, and adapts the instrument for use in the taking of transits, where extreme accuracy is not needed, and greatly adds to the value of the instrument.

Mr. Simms also exhibits a small equatorial, adapted for the latitude of London, but without clock motion. This instrument is upon the same principle as the preceding; it is understood to be inexpensive, but, as far as its size permits, it is an effective instrument. The focal length of the telescope is 46 inches, and its aperture $3\frac{1}{4}$ inches; it carries a parallel line micrometer, with powers of 50, 90, and 150, and the telescope is furnished with an illuminating apparatus. The hour and declination circles are 6 inches in diameter; the former is read by vernier to one second of time, and the latter to one minute of arc, with clamps and tangent motions.

The instrument surmounts an iron pillar, with a tripod stand, and there are screw adjustments, both for elevating the polar axis to the latitude, and for correction to the meridian.

The open declination axis and riding level occur in this instrument as in the former.

DOLLOND (No. 145), a portable equatorial, made for the late Capt. Kater, F.R.S. The object-glass of the telescope, which is 30 inches focus and 4 inches aperture, is worked from a formula of Sir John Herschel's, and performs extremely well. The instrument is supported upon a strong folding tripod, is furnished with divided circles, a finder, levels, and a complete set of eye-pieces.

The instrument is well adapted for seeking for comets.

SIMMS (No. 741). An altitude and azimuth instrument, known as the Westbury Circle.* The diameter of the altitude circles is 30 inches, and that of the azimuth circle is 24 inches. The divisions are cut upon a band of silver fitted into each circle, and situated near the circumference. The method adopted in graduating these circles was that invented by the late Edward Troughton, Esq., F.R.S., and described by him in the "Philosophical Transactions,"† as a method of dividing by the eye, to distinguish it from the old method of dividing by the hand.

The circles are divided into 360 degrees, each degree into twelve parts or spaces, and these are again subdivided to single seconds by two micrometer microscopes placed diametrically opposite each other upon both circles.

The microscopes for reading the altitude circle are fixed to the opposite ends of an arm which revolves about an axis concentric with, but perfectly independent of, the axis of the circle, which arm can be fixed in any position at pleasure. This contrivance, which, in effect, is the same as the power of changing the position of the telescope upon the mural circle was, we believe, first applied to this instrument.

The microscopes for reading the azimuth circle are fixed immoveably.

The azimuth axis descends within the pier to a depth of nearly three feet, and turns upon a steel point within a conical hole: the upper end of this axis is supported within a rectangular Y by openings opposite the points of bearing, and the axis can be corrected in regard to verticality by adjusting screws, which act upon the frame in which the Y is fixed.

The azimuth circle is screwed to conical radii which spring from the azimuth axis near its upper end.

The altitude axis resembles that of a transit instrument, and the diaphragm is illuminated through one of the pivots in the usual manner. From the central zone of the axis two sets of radiating cones diverge, and to the ends of these cones the circles are screwed, one on either side of the telescope. These circles are connected by cross pieces around the circumference, where they also lay hold of the telescope, which is thus secured against any considerable flexure, and the cones are braced together by two inscribed squares of brass, one upon each face of the instrument.

The object-glass was made by the late Charles Tulley: the diameter of its aperture is 2·7 inches, and the focal length is 36 inches. At the eye end there is a diaphragm of the ordinary kind, with five vertical and five horizontal spider-lines. The eye-pieces consist of both direct and diagonal, furnished with magnifying powers varying from 60 to 150.

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* For a full description of this instrument, see Pearson's "Astronomy," vol. ii. pp. 419-434.

† See the volume for the year 1809.

The transit axis is adjusted by means of a spirit-level; there is also a spirit-level applicable to the telescope for giving the horizontal point, and a plumb-line apparatus is fixed to the column by which the micrometer support is carried, and serves as a watch upon the stability of this important part of the instrument. The construction of this instrument is light and elegant, and, as experience has shown, it is capable of giving results of a high degree of accuracy; but the modern plan of forming astronomical instruments of as few pieces as possible, of which Mr. Simms has given specimens in the alt-azimuth and great transit circle at the Royal Observatory at Greenwich, is fast superseding the more elaborate, and if not less accurate, certainly less durable construction.

This beautiful instrument was made by the late Mr. Edward Troughton, at about the beginning of the present century, for Mr. Pond, the late Astronomer Royal, who, by the observations he made with it at Westbury, demonstrated the change of figure of the great mural quadrant then in use at Greenwich. After long exposure to the influence of the atmosphere, and consequent decay, it was in the year 1823 repaired and re-graduated by Mr. Simms, the Exhibitor.

Simms (No. 741). A portable altitude and azimuth instrument, with circles of 15 inches in diameter, having a telescope of 24 inches focal length, and of 1·9 inch aperture, with two direct eye-pieces of powers of 35 and 60, also a diagonal eye-piece magnifying 40 times.

This instrument is of the most recent form. A strong brass tripod supports the superior parts, to the centre of which the azimuth axis is fixed, and the azimuth circle is screwed upon its face.

A strong plate circulates upon the azimuth axis, carrying two pillars of massive proportions, by which the altitude circle is supported. To these pillars the azimuth microscopes are fastened, and one of these pillars carries two conical branches at its upper end, for the purpose of holding the microscopes by which the altitude circle is read, and a sensitive spirit-level is so placed as to detect any instability in these branches, and to give its amount in arc. The telescope and axis are formed like those of a transit instrument, and two circles are on each side of the telescope braced together with it by intervening pillars.

The circles were graduated upon Mr. Simms' self-acting engine, upon rings of silver, and the subdivision is made to single seconds of an arc by means of two opposite micrometer readings upon each circle. The microscopes of this instrument have achromatic object-glasses.

The transit axis is adjusted by the usual standing level, and each circle is fitted with a clamp and tangent screw motion.

The novelty in this instrument is the introduction of a central collimator—a ready means at all times of determining the nadir point: this important addition is the invention of Mr. Simms.*

The invention consists in placing a small achromatic telescope in the centre of the azimuth axis, which is perforated for its admission. It is furnished with a cross of delicate spider-lines in the focus of its object-glass, and has suitable adjustments.

* For a full description of this invention, see the 15th volume of the "Transactions of the Royal Astronomical Society."

If the principal telescope of the instrument be directed to the collimator, an image of the cross lines of the latter will be seen upon the diaphragm of the former; and as the collimator remains at rest, being in firm connection with the tripod upon which the instrument stands, it follows that if the superior parts of the instrument be turned round in azimuth, the axis of the two telescopes may, by adjustment, be made to remain perfectly coincident during an entire revolution.

If, in this state of things, the azimuth axis be set truly vertical by means of the spirit-level, which is fixed upon the instrument, the centre of the collimator becomes a nadir point to which all observations may be referred.

This *point* has additional uses; for instance, in performing the collimation adjustment of the telescope, and in setting the altitude axis at right angles to the azimuth axis, and would consequently supply the place of the transit level, if by accident the latter was broken.

The importance of this invention, especially to the scientific traveller, is obvious; and several such instruments have been made by the Exhibitor, and which are in use in the boundary survey of the United States, and on other similar services.

For the several inventions in these beautiful instruments, the Jury voted unanimously the Council Medal to Mr. Simms, and which award was also passed unanimously by the Group, but was not confirmed by the Council of Chairmen, and therefore Mr. Simms will not receive that kind of Medal to which the Jury considers him fully entitled.

CRICKETT (No. 267) exhibits a model of a stand for mounting an equatorial.

ERTEL and SON (Prussia, No. 25) exhibit a portable universal instrument, with horizontal circle of 15 inches in diameter, and two circles of altitude of 10 inches in diameter. The horizontal circle is divided to two minutes of arc, and is read by two micrometer microscopes to seconds; it is also furnished with four verniers, which read to two seconds. The divisions are fine, clear, and distinct. The circles of altitudes are well divided to four seconds of arc. The two reflectors for illuminating the division under the microscope are so made as to receive light from all sides.

All the clamps are applied to the centre to prevent any bending of the spokes, or affecting the figure of the circle.*

On fixing the lower clamp, the instrument was found to be absolutely fixed; and in this state was capable of being used as a transit circle. The level was

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* The axle clamp, as used by Troughton, is essentially different from that employed by Ertel. With Troughton it was a matter of convenience: with Ertel it is considered indispensable in order to obtain accurate observation. It is used for the horizontal circle of the Westbury circle, while the more important part, the vertical circle, has a clamp on its limb. In the Westbury circle the extremity of the arm of the clamp is fixed in the direction of its length as well as in the direction perpendicular to its length. This, in the case of the Westbury circle, strains the vertical axle. In the case of a transit instrument, it either bends the axle downwards, or lifts it out of the nearest Y, so that it touches one side of the Y only, or rocks from side to side. In the Munich instrument the axle clamp has a polished surface, which is made to press against the end of a screw by means of a spring or the tension of a spring by which a weight is suspended, and is acted upon by no force in the direction of the length of the arm. I find these clamps recorded as new in notes made during a stay at Munich.—W. H. M.

made to rest on three bearing points; it is good; and when placed on the instrument no motion of the vertical circles affected the horizontal fixity of the instrument, or *vice versâ*.

The horizontal circle is in fact composed of two concentric parts in the same plane, an inner one which moves on its own pivot, and revolves, without touching the outer part of the circle, and each moves independently of the other. The centring of these circles is beautiful.

There is a telescope of security, and which has its own motion, and can be set upon any object; and the fixity of the instrument when thus tested was found to be quite satisfactory.

At the intersection of the telescope with its horizontal axis is placed a right-angled prism. By internal reflection at the hypothenusal surface of the prism rays of light coming from the object-glass are reflected towards one end of the axis where the eye-piece is placed, so that in all positions of the telescope the observer looks in a horizontal direction: on the other end of the angle is a graduated circle of 10 inches in diameter, with four verniers (in the same plane as the graduated limb of the circle) each reading to 4″. The vernier circle carries a level moveable round the axis of the vernier circle, and capable of being clamped to it in any position with the level fixed: a double-zenith distance of any object may be observed on one part of the limb. The level may then be fixed in any other position, and the double-zenith distance measured on any other part of the limb.

The supports of the horizontal axle of the telescope rise from a strong horizontal piece of metal, to which is attached a vertical steel axis, passing through a vertical cylinder terminating below in a tripod with foot-screws. The steel axis carries a horizontal circle, graduated by a line at every three minutes, and also two arms carrying micrometer microscopes. The vernier circle (15 inches in diameter) has a hollow axle which fits on the outside of the cylinder through which the axle of the vernier circle passes, and is capable of being made to revolve in its own plane. Attached to the end of the vernier circle is a check telescope with a vertical wire moveable by a micrometer screw.

The vernier circle is graduated by lines at every two minutes. This graduation is read to seconds by each of the two microscopes. The vernier circle being capable of revolving in its own plane, horizontal angles may be measured on different parts of the arcs by both the verniers and the microscopes. The microscopes have two wires very close to each other parallel to the division in the centre of the field. In observing, the image of the division is made equidistant from the two parallel wires. The axle of the telescope has a striding level for determining its horizontality.

Troughton objected to repetition in large instruments. Zach and Bohnenberger had shown that repetition introduced errors larger than those it was intended to correct in well-graduated vertical circles. Struve found that even in the measurement of horizontal angles it was much better to measure the angles on different parts of the arc than to repeat. Accordingly, this instrument is constructed to measure horizontal angles and double-zenith distances, but not to repeat. In the older instruments constructed by Reichenbach and Ertel the circles were made to clamp at their circumference.

In a universal instrument, having a horizontal circle of 24 inches diameter (used by Struve as the principal instrument for the triangulation for the Russian arc of the meridian passing through Dorpat), when clamped at the circumference, on turning the slow-motion screw, the spokes were found to ~~head~~ bend through an angle of nearly 8″ without moving the telescope. In order to avoid this source of error, the clamps are applied to the axes of the vertical and horizontal circles of the instrument.

The heads of the foot-screws are graduated: this facilitates the operation of levelling the instrument, and also enables the observer to measure the angle corresponding to a division of either of the levels.

The axle-clamps at the extremity most distant from the axle have flat surfaces of polished steel. This surface is pressed by a spring against the point of the slow-motion screw. By this contrivance the axle is prevented from rotating, without the danger of straining or bending it, or lifting a horizontal axis out of its Ys, which might happen if the outer extremity of the clamps were fixed, as in the axle-clamps that have been used in this country.

It is called a universal instrument because it is a transit instrument, and serves also to measure zenith distances and horizontal angles. It is the invention of the firm now represented by Ertel.

The double wires (vertical for the telescope—probably 20″ distant from each other) were the line introduced by Reichenbach or Ertel. When a single line is made to bisect a very faint object, the object is extinguished. This is not the case when the object is made to bisect the space between two wires 20″ asunder, though it would be if the wires were much closer.

The telescope is diagonal, and consequently only one-half the usual length, the eye, in observation, being always at the axis; and by this means observations can be made in the zenith.

There are on the inner portion of the horizontal circle 10,800 lines, and on the outer portion 7,200, or, altogether, 18,000 lines, as fine and distinct as on the largest astronomical instrument. This piece of work alone occupied a fortnight, working many hours daily; and it is a masterpiece of hand-dividing.

M. Ertel's objects have been, the combining of the greatest possible simplicity with the greatest possible firmness.

This form of instrument, invented by M. Ertel, has been used with great success in the measurement of the arc of the meridian, by Struve.*

The Jury voted to Ertel and Son a Council Medal for this beautiful instrument, which award was sanctioned by the Group; but unfortunately did not pass the Council of Chairmen, who only sanctioned the Prize Medal.

MERZ and SONS (Bavaria, No. 30) have exhibited an equatorial, with the polar *axis adjustable within certain limits, so as to adapt* it both as a portable instrument, and applicable to different latitudes within those limits. The focal length of the telescope is 4 feet, and the object-glass has an aperture of 4 inches, a very unusually large aperture for this size of telescope, admitting a large pencil of light, and thus adapting the telescope for faint objects.

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* For a description of this instrument see "Description de l'Observation Astronomique Central de Poulkova," par F. G. W. Struve, and dans le "Recueil des Actes," pour l'année 1834.

It is furnished with powers magnifying 20, 64, 96, and 216 times. It has an hour circle, and a declination circle, both of 7 inches diameter.

The workmanship of this instrument is good, and fully sustains the justly-celebrated name of the maker.

The telescope was tried twice; first, by Sir John Herschel, Lord Wrottesley, and Mr. Glaisher, who reported of the object-glass as being first-rate; and secondly, after the lapse of a month, by Sir David Brewster, M. Matthieu, and Mr. Glaisher, whose report was, that the secondary spectrum was not completely corrected, and this appearance was attributed by Mr. Glaisher to a disturbance of the lenses, since the first examination. At the time of the second examination the image of the sun was good, and the spots on his surface, with their penumbra, were well shown.

A Council Medal was awarded to Messrs. Merz for this instrument.

W. Bond and Son (United States, No. 413) exhibit an apparatus for observing transits, by means of a galvanic current. It consists of an electric break-circuit clock, a galvanic battery of a single grove's cell; connecting wires; a cylinder, around which paper is wrapped, and a spring governor, by which a uniform motion is given to the cylinder.

The clock is like those in common use for astronomical purposes. The pallets and the escapement-wheel are insulated, both from the pendulum and from the other wheels. When the battery is in connection, the circuit is broken by the pallet leaving the tooth of the wheel, but is restored at the instant of the beat of the clock, which is in fact the sound produced by the completion of the contact restoring the circuit; the passage of the current being through the pallet and the escapement wheel alone.

Two wires pass from the clock, one direct to the battery, and the other through the break-circuit key used by the observer, and through the recording magnet, back to the battery.

The electro-magnet, with a slight difference in the form of the armature, is the same as that of Morse's telegraph. The armature carries a glass pen, supplied with ink from a small reservoir. Under this pen the paper revolves, on which the records are made. The breaking of the circuit by the clock, every second, is marked by an offset made by the pen; and the breaking of the circuit by the observer, is similarly recorded, between the second marks of the clock. Unless a motion perfectly uniform is given to the cylinder, the second marks at the end of the hour, instead of being arranged in regular straight lines upon the paper, will change their relative positions. Uniform motion is given to the cylinder by means of an apparatus called a spring governor. The train of wheels which communicate the motive power to the cylinder is connected with a small fly-wheel. This fly is for supplying momentum, and near it is placed a half-seconds' pendulum, with a dead-beat escapement. The connection between the escapement-wheel and the fly is through a short spring. The elasticity of this spring allows the motion of the escapement-wheel to be completely arrested at each vibration of the pendulum, while the momentum of the fly, acting for a small fraction of a second only on the spring, keeps up the motion of the cylinder.

The cylinder revolves in one minute; the second marks in a continuous spiral.

In observing, the observer with the break-circuit key, at the instant of the transit of a star over the wire of a telescope, touches the key, and the record is instantaneously made on the paper.

In the ordinary method of observation of transits, the observer listens to, and counts the beats of a clock, whilst his eye is directed to the object passing the wires: thus he combines the two senses, of hearing and seeing, in such manner as to be enabled to compute, mentally, the fraction of the second when the object passes every wire, the time of which he then writes down in an observing-book, still listening and counting the beats of the clock, and so on till the object has passed all the wires. In this new method, he observes with his eye the passing of the heavenly bodies, and at the same instant touches the break-circuit key: with this apparatus it is evident that a signal almost instantaneous in duration can be recorded, by the momentary interruption of the circuit.

The practicability of this method of recording observations is placed beyond a doubt by experience in America, and from the results there obtained, this method would appear to be more accurate than that usually adopted by the combination of the eye and ear. The question yet remains to be determined, whether there be a closer connection between the nerves of the eye and the ear, or between the nerves of the eye and the finger, and this question can be settled only by experiments.

The Council Medal has been awarded to Messrs. Bond.

Nautical Instruments.

Exhibitors of nautical instruments are few in number, and with the exception of those exhibited by ERICSSON (United States, No. 146), and those by ST. JOHN (United States, No. 95), display but little novelty, and no decided improvements.

The sea-lead, and the several other instruments exhibited by Mr. Ericsson, reflect high credit upon him: they are original in their design, well adapted for their work, and useful.

Nautical Astronomical Instruments.

SIMMS (No. 741) exhibits a Troughton's reflecting circle, 10 inches in diameter, with three equidistant verniers reading to 20″ of arc, having an achromatic telescope with eye-pieces magnifying 8 times and 15 times, supported upon a counterpoise stand, with motions for placing the instrument in a vertical, oblique, or horizontal plane.

This instrument was invented by the late Edward Troughton, and was designed as an improvement on the reflecting circle, previously in very general use. With it, a cross observation gives six readings upon the circle, which is perhaps as high a degree of accuracy as is attainable by any instrument held in the hand, and such an observation is obtained with much less labour than one claiming equal confidence upon the ordinary repeating circle.*

Mr. Simms also exhibits a Troughton's sextant, fixed upon a counterpoise stand; this instrument was contrived for the purpose of combining strength with

* For a full description of this Instrument, see Pearson's Astronomy, and Encyclopædia Metropolitana, vol. i., p. 638.

lightness, and consists of two thin frames of brass, united by pillars. This form was suggested to the inventor by his having observed, that with one of the large open-framed sextants a contact of the sun's limbs made with the telescope directed upwards was but apparent, a large space occasionally intervening when the telescope was directed downwards into an artificial horizon.

This form of sextant has not only maintained its ground, but would appear by those exhibited to be fast verging on general adoption. It is usually made of 8 inches radius, and is divided to 10″ of arc.

A Prize Medal was recommended by the Committee upon Sextants for these instruments of Mr. Simms.

Barrett (No. 349) exhibits several sextants, one of which is furnished with a magnifier, prepared for reading without shadow by night; the instruments are for the most part of an ordinary character, nevertheless Honourable Mention was awarded to Mr. Barrett.

Crichton (No. 452) exhibits many sextants, some of a very ordinary kind; there are two, however, numbered 2251 and 2252, which are well made, but the divisions on the vernier and on the limb do not agree in any of them. In connection with drawing instruments, &c., a Prize Medal was voted to Mr. Crichton.

Mrs. Janet Taylor (No. 350) exhibits a sextant intended rather for show than use. Other exhibitors of sextants are Elliott and Sons (No. 322); Watkins and Hill (No. 659); and Dixey (No. 271).

Molteni and Siegler (France, No. 649) exhibit sextants and reflecting circles, pretty good in all respects, the divisions excepted. The Jury awarded these instruments Honourable Mention.

Vedy (France, No. 719) has exhibited a reflecting Borda's circle divided to 20′, and read by means of verniers to 20″. A reflecting circle made after the improvements of Captain Richards, by means of which very large angles may be measured.

A sextant read by verniers to 20″; another divided to 10′, and read by a vernier to 10″; a third and fourth, reading to 15″; a fifth, whose reading is to 30″; and a sixth, which reads to one minute. M. Vedy also exhibits an artificial horizon. These instruments are well made, and a Prize Medal was awarded to M. Vedy.

Buron (France, No. 443) has exhibited various sextants and octants in ebony and brass, furnished with coloured glasses to the number of five or seven, and with both direct and inverting telescopes. The sextants are divided to 10′, and subdivided by verniers to 10″. The size and the construction of these instruments are in every respect like those made in England. Their divisions are good, and their price is low.

Beyrther (Belgium) exhibits a sextant of 7·5 inches. The graduations are on silver to 10″, sexagesimal, with every means for verification. The body of the instrument is in one piece, and is very solid; a second sextant of the same size, divided, &c., as the preceding; another sextant of 6·3 inches radius, furnished with the same accessories as the preceding, and reads to 15″ sexagesimal; a fourth sextant of 4·3 inches radius, divided to 20″ sexagesimal; a fifth sextant of 2·8 inches radius, divided on silver to sexagesimal minutes; a sixth sextant of ebony 9·4 inches radius, divided upon ivory to 30″ sexagesimal; also an octant in ebony of 10·6 inches radius, divided on ivory to sexagesimal minutes, and two artificial horizons. The sextants are solid and well made, and the work of all is good.

A Prize Medal was awarded to M. Beaulieu.

OERTLING, A. (Prussia, (1) No. 87) exhibits sextants whose divisions on the limb are faint, but good; the verniers are such that it is difficult to judge of the reading to 10″ in the larger, and to 16″ in the smaller sextants.

IMPERIAL IJORSK WORKS (Russia, No. 169) exhibits two of the largest sextants in the Exhibition, being 10 inches radius. These are sound and well made, and reflect credit upon the artists.

ASHE (No. 194) exhibits an instrument for determining the course which a ship must steer to sail on a great circle. That the instrument will do its work is more than probable; but whether it has any advantage over the published tables for the same purpose is more than doubtful.

Various Nautical Instruments.

ERICSSON (United States, No. 146) has exhibited a sea-lead. This instrument, which is designed for making soundings at sea, independently of the length of the lead line, and without the necessity of rounding the vessel to the wind, is a modification of an instrument formerly constructed in conjunction with Mr. Ogden, of Liverpool.

The instrument consists of two large tubes; a chamber is placed immediately behind, and connected by means of a small bent orifice to the upper extremity of one of them. The top of the second is connected by a similar orifice to a third small tube suspended in the centre of the chamber. A stopcock is placed at the lower end of the glass tubes for the purpose of cutting off communication, if necessary.

The lead being bent to the line is lowered into the sea; as it sinks, the water enters the chamber, and gradually rising in it and in the tube suspended within, causes an increased pressure upon the air, which is driven through the orifices into the glass tubes. The tube which is connected with that in the chamber will be entirely filled with the air thus forced into it from the suspended tube, the water will consequently rise, and its reading may be observed upon the graduated scale with which the instrument is furnished for that purpose.

The contents of the chamber being much greater than that of the tube suspended within it, the air with which it is filled will not be compressed sufficiently to admit water into the glass tube connected with it until the lead shall have descended to a depth of 25 fathoms. This tube is therefore well adapted for the measurement of deep soundings, whilst the other registers small depths, which otherwise could not be indicated. This instrument in its use is attended with less loss of time than the casting of the ordinary deep-sea lead.

Mr. Ericsson has exhibited an instrument for measuring distances at sea. This instrument is intended chiefly for the use of naval officers, to enable them to determine, by means of a single observation taken at sight, the distance of a vessel, either advancing to or receding from the observer.

If the eye be placed at a certain height above the level of the sea (say on the main-top of a ship), the vertical angle, formed by a line passing from the eye to any fixed point in the horizon, and a line from the eye to the water-line of the hull of a vessel in the distance, will become greater as the vessel approaches to, and will become less as the vessel recedes from, the spectator: to measure this angle and to determine the distance of the ship, is the chief purpose of this instrument, which is composed of the following parts:—

An ordinary reflector, an object-glass, and a sight for measuring angles. The reflector is attached to the end of a spindle which is turned by means of a lever. At the lower end of this lever, in a slot, a sliding nut moves freely up and down, in which a thumb-screw is made to work. A pinion on this screw works into cogs cut in the circumference of a graduated index-plate, which is supported upon a frame, and revolves by means of a socket in a centre piece. The scale of the index-plate is graduated into yards for every variation of distance of 10 yards, from the horizon to 400 yards' distance from the ship, as viewed from an elevation of 100 feet. For these, and the other beautiful instruments exhibited by Mr. Ericsson, a Prize Medal was awarded to him.

Keller (France, No. 280) exhibits a double planisphere, designed to assist navigators in great-circle sailing. It consists of two concentric circles, the one fixed and transparent, the other moveable.

St. John (United States, No. 95) has exhibited a very ingenious self-detector compass. In appearance it is very similar to the ordinary box-compass, and differs chiefly in the following particulars:—upon the compass card, and attached to it by pins, are two small needles, called satellites; to the centre of each a brass indicator is fixed; on the face of the card are engraved two semicircular scales, or arcs of circles, so placed that their centres are in the centre of the compass card, and in a line joining the centres of the satellites: both these scales are graduated to degrees, the numbering of the graduation proceeding on either side from the central point of each scale. The satellites are balanced upon pins, move freely, and thus permit the brass indicators to move easily over the graduated arcs, according to the amount of disturbance. The satellites and the main needle being equally magnetized, remain stationary when there is no cause of disturbance in the magnetic meridian, and the brass indicators point to their respective centres; but, should there be any cause of disturbance, the indicators move simultaneously in opposite directions, thus indicating its amount; and if the course of the disturbance be local, the indicator attached to that needle, the nearest to the seat of disturbance, will pass through the greater angle, and thus the direction of the disturbing cause is shown.

Mr. St. John has also exhibited an aquatic velocimeter. This instrument is designed to show upon a dial-face the distance traversed by a vessel in a given time, and its velocity. Upon the dial are three circles, each provided with an index, and so graduated that the first performs one revolution in a mile, the second in 100 miles, and the third in 1,000 miles. The motion is communicated to the clock mechanism by means of several mechanical adjustments, within a tube, which is inserted in the bottom of the vessel, and protected from injury by a coating of India-rubber, and a wooden box, by which it is completely enclosed. The chief part of the mechanism consists of a revolving shaft, which receives its motion from a paddle-wheel attached to it. The water acting upon its fans causes it to turn round, the shaft in connection with it performing one revolution in a distance of 4 feet. The arrangement also includes a metal frame, and pistons to obviate any danger which might arise from the position of the pipe within the vessel; there are also facilities for disconnecting the apparatus from the clockwork, for the purpose of setting the index to any time or point desired. This instrument is new, and seems to be well adapted for its work. The Jury consider much merit due to Mr. St. John for these inventions, and award the Prize Medal to him.

Surveying Instruments.

The instruments exhibited in the British portion of this section are few in number, and, with the exception of those by Simms, Dollond, Marratt, and Yeates, are, for the most part, of an ordinary kind, there being neither improvement nor attempt at such in their construction.

In the Foreign Department it is otherwise. In Belgium may be found Beaulieu worthily following in the steps of his celebrated master, Gambey. In Germany, Breithaupt's admirable method of covering the divisions of the circle by a thin circular plate seems to be generally adopted, and commands attention. The further improvements which he has introduced in his surveying instruments will be detailed presently.

The Polytechnic Institute of Vienna has exhibited various instruments for levelling, which present many improvements, the result of more than an ordinary degree of attention. Mr. Burt, of America, has exhibited a compass well adapted for surveying.

Surveying and Levelling Instruments.

Simms (No. 741) exhibits a transit theodolite. This kind of instrument was introduced a few years since by Mr. Simms; it is intended especially for the use of the scientific traveller and civil engineer. It is, in fact, an extremely-portable altitude and azimuth instrument. The ordinary vertical arc of the theodolite is extended to a complete circle, and is read by two opposite verniers. The range of the telescope is unlimited, like that of a transit instrument, and by means of a diagonal eye-piece, observations can be made in the zenith. The axis is perforated for illumination of the field of view. The instrument is 8 inches in diameter; it is graduated in silver to 10″ of arc; its readings are by means of verniers. By estimation the angle can be read to less than 5″.

The telescope is 13 inches in focal length, and 1¼ inch aperture, and is furnished with magnifying powers of about 25 and 40 times. The magnetic needle, spirit-level, lamps, and tangent-screws, and other fittings do not differ materially from those usually adapted to theodolites of the best construction.

Dollond (No. 145). A transit theodolite. The circles are 12 inches in diameter, each reading by verniers to every 10″ of arc. The telescope fixed to the altitude circle is 20 inches focal length, and 1·6 inches aperture, furnished with direct and inverting eye-pieces, and is supported on Ys, on two strong cones resting on the azimuth circle The compass is 5 inches in diameter and divided to every degree. The spider-lines are illuminated in the usual manner through the axis of the altitude circle.

Yeates (No. 332) exhibits a very portable small theodolite, with good divisions, well made, and strongly put together. It is furnished with one large spirit-level.

Also a 4-inch theodolite, displaying good workmanship; a prismatic compass with a spirit-level attached, and an optic square, intended for use in determining distances. All these instruments are well made, and deserving of Honourable Mention.

Marratt (No. 409) exhibits a 7-inch theodolite, which reads to 15″. It is furnished with a locking-plate and tripod. The lower portion consists of a massive tripod with foot-screws, to which is fixed the centre on which the instrument revolves. The lower limb is in one piece, and is furnished with tangent-screws and three verniers. The exterior centre and Ys for the support of transit axis are cast in one piece, and to which is attached a spirit-level. The telescope is soldered to the axis, and the vertical circle is firmly screwed to it, so that the vertical circle, axis, and telescope are firmly connected. The whole instrument is formed of the smallest number of pieces, with the view of preventing flexure and insuring stability. The Jury awarded Honourable Mention.

Joseph (Canada, No. 182) exhibits a 6-inch theodolite of very indifferent workmanship.

Elliott and Sons (No. 320) exhibit an altitude and azimuth instrument of the ordinary construction. It is understood that this instrument is intended chiefly for surveying purposes; it is coarsely divided. They also exhibit two transit theodolites, the one of 5 inches and the other of 6 inches diameter. These instruments were not adjusted. Messrs. Elliott and Sons also exhibit dumpy-levels of good workmanship. In those exhibited, the index-bar on which the level rests is placed vertically, instead of horizontally, as they were in those by Mr. Garratt, the inventor of this kind of level. Also there is a change in the mode of adjusting the bubble: instead of the use of three screws at either end of the bubble, there is one strong joint at one end, and a screw at the other; the joint cannot move till the screw at the other end is loose, and it is so constructed that it is almost impossible to become loose by travelling; and they exhibit an instrument based upon the principle of similar triangles, adapted for the determination of distances.

Bridges (No. 339) exhibits an instrument to determine the distance of objects, either by night or by day, and rules are given to determine the distance when the height is known, or when its breadth is known, or when neither is known, and also to determine the same by night.

Barton (No. 708) has exhibited an instrument designed for sketching ground, for military purposes, with great rapidity. It is designed with a view to its being manageable in the hands of men engaged in military service, without regard to their scientific acquirements. Its simplicity of construction renders it very inexpensive.

For description of this instrument, see Illustrated Catalogue. Honourable Mention is given to this Exhibitor.

Liddell (No. 362) has exhibited pocket-sight and field-sight spirit-levels to the number of 30, as used by mechanics, and adapted for drainage, road surveying, &c.

The spirit-levels are exhibited on account of lowness of price: some of the sight-levels are furnished with reverse sights; there is one level with a revolving shade, intended as a safeguard to the level tube.

Adcock (No. 353) has exhibited a machine for drawing and mapping roads.

Green (No. 446) has exhibited a miner's compass.

COX (No. 347) has exhibited a beam draining level, with adjusting parallel plates on tripod stand. It is a simple and inexpensive instrument, giving, by inspection, the rise and fall of land intended to be drained. It is also useful in laying tiles, levelling, and in building operations. Mr. Cox has also exhibited an A level, to be used without either parallel plates or tripod stand.

BLYTH (No. 367) exhibits four levels, of different lengths, with stand and small telescope.

DOBBS (No. 346) exhibits a spirit-level, applicable for levelling machinery.

HORNE, THORNTHWAITE, and WOOD (No. 220) exhibit an angular spirit-level, showing the rise and fall in inches and parts. It is adapted for agricultural purposes.

DENTON (No. 317) exhibits a workman's draining A level, with a bob, intended for the use of farm labourers; and a second level of the same construction furnished with a spirit-level.

WILTON (No. 402) exhibits a miner's theodolite.

BURON (France, No. 443) exhibits a repeating theodolite with concentric circles, 8·7 inch diameter, divided to 10′, and read by four verniers to 10 seconds. It is furnished with two telescopes of 17·7 inches in length, and apertures 1·2 inch. The vertical circle is 4·3 inches in diameter, and is divided to 30″. Mr. Buron also exhibits several levelling instruments.

BEAULIEU (Belgium) exhibits a repeating theodolite, of the form used by Gambey. Its circle is 13 inches in diameter, divided on silver to 10 centesimal minutes, read by means of 4 verniers to 10 seconds, and is adapted to take either horizontal or vertical angles.

The azimuthal circle is 8·7 inches in diameter. It is divided upon silver, and is read by a single vernier. It is furnished with two levels. The telescope is 1·8 inch aperture, and 19·3 inches focal length. There is a counterpoise attached, to be used when vertical angles are to be taken. This instrument was constructed for the Dépôt de la Guerre, in Belgium, for which service all the instruments are divided upon the centesimal system; but M. Beaulieu has likewise divided this instrument sexagesimally, the principal circle reading to 4 seconds of arc, and the azimuthal circle to 20 seconds. All the divisions of this instrument are very good, as indeed is the workmanship of the whole instrument, and the sextants exhibited (see Section, Nautical Instruments); a Prize Medal was voted to M. Beaulieu.

GROETAERS (Belgium, No. 156) exhibits an instrument for determining the distance of inaccessible objects. It is stated that the results obtained by the use of this instrument have been good.

DE HENNAULT (Belgium, No. 183) exhibits a miner's compass, intended for use in determining the co-ordinates of a mine.

LAMBERT (Belgium, No. 185) exhibits a smaller miner's compass, but not so well made as the preceding.

BECKER (Netherlands, No. 83) exhibits a levelling apparatus.

BREITHAUPT (Prussia, No. 670) exhibits a theodolite. In this instrument, as in most theodolites of German make, the circle which carries the verniers is let into, and surrounded by, the graduated circle, so that their upper surface, on which the graduations are traced, are in one plane. In order to protect the divisions from dirt, rain, and from mechanical injury, the vernier circle carries a thin circular plate of brass, which completely covers the graduated or outer circle, with the exception of two openings, covered with plate glass, through which the verniers can be seen.

This useful covering for the graduations, though now used by other artists, was, we believe, first introduced by Mr. Breithaupt.

Mr. Breithaupt also exhibits a level, which instead of having circular collars on the telescope, which it is difficult to make of equal diameter, and, if accurate when the instrument is new, are very apt to bear unequally, has towards each end of the telescope a knife-edge, and opposite to it, on the other side of the tube, a steel screw with a convex head; one knife-edge is on the upper side of the tube and one on the lower side. The level is attached to a plate of steel, having its under surface ground truly plane. By turning the convex-headed screws, the planes through the knife-edges, and touching the heads of the screws, can be made parallel to a line joining the centre of the object-glass and the intersection of the cross wires, and therefore to each other. The line of collimation of the telescope will be truly horizontal when the bubble of the level maintains the same position before and after inversion. This contrivance greatly increases the facility of adjusting a level, and of rendering the person using it independent of the skill of the maker.

It is a common error among surveyors to assume that the circular collars of a level are of equal diameter; and as long as this belief prevails, this invention must be of peculiar importance.

Mr. Breithaupt also exhibits a mining theodolite. This instrument is attached to its tripod by a slightly-conical socket, and the graduated circle is made horizontal by two screws, opposed by two strong springs. The graduation of the horizontal circle is to 30″ and has two verniers. Its diameter is nearly 4½ inches. The vertical circle, which is about the same diameter, is also read to 30″ by two verniers.

The telescope, whose aperture is about 11 lines, at the place where it meets the horizontal axis, has a right-angled prism, which reflects the rays coming from the object-glass. At one extremity of the long horizontal axis are placed cross wires, adjustable by rack and pinion, and an eye-piece, adjustable by screwing, similar to those of the levels. The telescope can be pointed to any object, from the zenith to a depression of 50° or more below the horizon, and can be clamped, at any altitude, to an arm which is moved by a micrometer screw; and thus distances can be measured from one station, by observing the altitudes or depressions of two fixed marks on a staff. A level, like that of the transit instrument, is applied to the axis of the telescope. (Prize Medal awarded.)

LÜTTIG (Prussia, No. 81) exhibits a levelling protractor, the divisions of which are good.

KINZELBACH (Bavaria, No. 26) has exhibited a surveying cross, being a cone of brass, with two pairs of fine slits, for sights, at right angles to each other, running obliquely up its sides, and revolving on a base, the circumference of which being graduated, is read off with a vernier, the whole being screwed on the top of the surveyor's rod.

Mr. Kinzelbach has also exhibited a diastimeter, or distance-measuring instrument; being a telescope, provided with a micrometer and divided scale, the micrometer being mounted with two parallel wires, moveable simultaneously along a scale, graduated to minutes, so as to remain at equal distances from the centre of the field of view, and thus to embrace the area of greatest distinctness in all cases. Also an improved Wollaston's goniometer.

IMPERIAL POLYTECHNIC INSTITUTE OF VIENNA (Austria, No. 130) has exhibited several beautiful instruments, constructed according to the plan suggested by Professor Stampfer.

1. A large level.* The aperture of the object-glass is 15 lines, and the power 20. The support of these levels consists of three feet, attached to the sides of a triangular prism by strong screws. The upper part of the prism is a truncated cone, fitting into a slightly-conical socket, which forms the lowest part of the brass-work of the level. This socket is clamped very firmly on the stand by a single turn of a screw, so that the level can be readily attached to, or removed from, its tripod. The lower part of the level consists of two circular plates, connected by a ball and socket, as in the levels constructed in this country. But instead of four screws for making the upper plate horizontal, the Austrian level has two screws and two strong springs, the screw being at one end, and the springs at the other end of each of two diameters of the plates, at right angles to each other. By this contrivance the upper circle is more quickly and easily made horizontal than in many other known instruments of this kind, without the danger of either shaking or bending the plates, attendant upon the use of four screws.

The upper circle, which is about 4½ inches diameter, is graduated, and has two verniers, reading to 30″.

The greatest improvement introduced into this level is a micrometer screw, by which an angle in a vertical plane, if not more than 8°, can be determined to within 1″ or 2″ of the truth. This screw is of great use, in making the telescope very accurately level, when the instrument is employed in the ordinary manner, and the situation of the levelling staves so chosen that they are intersected, at some point of their length, by a horizontal plane through the axis of the telescope. By the aid of the micrometric screw, however, the difference to the altitude of two stations can be determined, when it greatly exceeds the length of the levelling staff. For this purpose the staff carries two marks, at a known invariable distance from each other. The angular altitudes or depressions of these two marks, measured by the micrometer screw, serve to determine, with great precision, not only the inner elevations or depressions of either mark above or below the axis of the telescope, but also its horizontal distance from the centre of the instrument. These distances, combined with the difference of azimuth of the stations observed with the horizontal circle, afford data for constructing a map of the country passed over in levelling. The selection of stations in this mode of levelling is limited only by the condition that the elevations or depressions of the marks shall not exceed 8°. By one observation, differences of level of 100 feet between two stations may be measured : thus the stations may be taken at much greater distances from each other than in levelling by the old method. This advantage is particularly felt in levelling through a hilly country. By means of this instrument the altitudes of distant objects may be measured with great precision.

The telescope is adapted to the distance of the object observed by a sliding tube

* See the 20th volume of the Polytechnic Institute.

carrying the cross wires, moveable by a rack and pinion. This tube moves between three bearings, attached to the inside of the outer tube, at equal distances from each other: one of these is a spring wheel, which, by its constant pressure, prevents all shake of the tube carrying the micrometer. The telescope is adapted to the focal length of the eye of the observer, by having that lens of the eye-piece which is next the eye set in a cap, which screws on the end of the tube, and by turning it is brought to the proper distance, to give distinct vision of the cross wires.

2. Smaller levels, of similar construction, in one of which the telescope has a power of 15. In another the power equals 12. A fourth is similarly constructed, with the exception that it has no horizontal graduated circle: the power equals 6.

3. Two pocket telescopic levels.

4. A ruler for plane-table surveying, with a telescope provided with a micrometer screw, similar to that of the large levels for measuring distances.

5. A ruler for plane-table surveying, with telescopic sight. The Jury awarded Honourable Mention for these instruments.

Schrödter (Prussia, No. 484) exhibits a six-inch theodolite, of very good workmanship. The Jury awarded Honourable Mention to Mr. Schrödter.

Imperial Ijorsk Works (Russia, 169) exhibit a levelling instrument, mounted on a well-braced and very firm tripod stand. The instrument is well made in every part, with good divisions, and reflects credit upon the artist.

Burt (United States, No. 187) has exhibited an "astronomical compass," an instrument intended for the survey of lands, bays, &c., for the determination of latitudes, apparent time, and the magnetic declination.

It consists of two plates of about 6½ inches in diameter: the upper revolves about the lower by means of a centre-piece, which, when fixed, leaves the under plate to revolve freely. The two plates can be clamped together by means of two clamps. The upper side of the lower plate is divided, the graduations being seen through two openings in the upper plate, and which are furnished with verniers. A small magnet is placed on the upper plate for determining the declination. To the upper plate is fixed a grooved arc, a latitude arc, a declination arc, an hour arc, two spirit-levels, &c. The latitude arc is fitted to one end of a curved bar, the other end of which is in connection with the hour arc, and can be adjusted to the latitude of the place. The declination arc is placed upon a limb which revolves equatorially upon a centre, and there is a second moveable limb turning on a pivot at one end, and furnished with a vernier at the other, moves on the declination arc, and affords a means of clamping it to the sun's declination. To each end of a moveable brass limb a small brass plate is attached at right angles: into the upper side of one, and to the lower side of the other, a small convex lens is inserted, fitted with a sliding shade, through which there is a small hole: opposite to each lens is fixed a small silver plate; on these plates fine lines are drawn, sufficiently separated to include the image of the sun. The arcs of latitude and declination have each a radius of 5 inches, and are graduated to 15′, and read by verniers to single minutes. The hour circle has a radius of 2½ inches, and is divided to half degrees. The instrument is furnished with every means of adjustment and verification. It is well adapted for surveys in new districts, and has rendered good service in magnetic districts, where it is understood that instruments constructed with magnetic compass have failed. The Jury voted a Prize Medal to Mr. Burt.

Standard Measures of Length.

WHITWORTH AND Co. (Class VII., No. 201) have exhibited a standard bar measurer. This machine consists of a metal frame, at each end of which is placed a micrometer; that to the right hand is a combination of a screw about ten threads to the inch, of a tangent screw and wheel with 400 teeth, and also a circle with 250 divisions. Therefore the divisions on the circle indicate $\frac{1}{10}$th of $\frac{1}{400}$th of $\frac{1}{250}$th of an inch, or of one-millionth part of an inch. The micrometer placed at the left hand is furnished with a screw with ten threads to one inch, and a circle divided into 500 parts, and thus one part of the circle corresponds to $\frac{1}{5000}$th part of an inch. On the upper side of the frame, and extending through its whole length, is placed a half-square groove made of steel, with its angle downwards, and its upper edges horizontal. In this the measure is placed. Between one end of the measure and the point of the right-hand micrometer, a perfectly-flat contact piece of metal is placed, with its sides parallel; the other end of the measure abuts against the left-hand micrometer.

There are two methods of determining when contact takes place, and hence the length of the standard measure.

1. By that which is termed the test of gravitation.
2. By that which is termed the galvanic test.

(1.) The test by gravitation is as follows:—

The experimenter moves the end of the screw of the right-hand micrometer through one-millionth of an inch, by means of the right-hand micrometer; then carefully raises the contact piece, and allows it to fall by its own gravity: he then moves a screw through a second millionth of an inch, raises the contact piece as before, and so on, till the approach of the end of the micrometer screw to the end of the measure prevents the contact piece from descending. This completes the measure.

(2.) The galvanic test is as follows:—

There is a small battery composed of a piece of zinc and copper soldered together and immersed in rain water, without the admixture of any acid; this is connected with the micrometer (which is insulated from the machine), and with a delicate galvanometer by means of covered wires. The measure itself is also insulated from the machine.

By pursuing the same process as before, contact is indicated on completing the circuit by the deflection of the needle of the galvanometer.

This beautiful and delicate apparatus seems to be capable of improvement: the ends of the measure exhibited are perfectly flat, and of its full size; the contact pieces are somewhat smaller, but the constant and repeated contact must wear the ends away, and soon alter its length. For a standard bar, it would certainly be better to insert at its ends a smaller contact surface, of a substance much harder than steel. A Council Medal was awarded to Messrs. Whitworth. (Awarded also in Class VI.)

BAUMANN (Prussia, No. 76) exhibits Bessel's standard measure. It consists of a solid beam of mahogany 4 feet 6½ inches in length (Prussian measure), 7 inches 2 lines square. The two 3-feet bars to be compared are placed upon a carriage on five wheels, which run on rails in a direction at right angles to the length of the bars. At each end of the carriage are receptacles for the bars with screw adjustments for placing them in a proper position for comparison. At each end of the beam is placed a micrometer, consisting of a slider moved by a screw having about 400 turns to the inch. On the slider are two Ys, in which rests a cylinder of steel about 7 lines in diameter and 4⅙ inches long. The inner end (viz., the end directed towards the middle of the beam) is ground convex, the other end is a cone. The point of the cone rests against a vertical plane of steel attached to the axis of a "fühlniveau" (level contact) at a point about 0·25 inches from the axis. The bars to be compared (bars of steel not hardened 0·75 inches square, having their ends on rather a small circular disc at either end, which is made of hardened steel, ground truly plane), are placed on the carriage, with their axis about 1⅓ inches asunder. The carriage is moved till the axis of one of the bars coincides with the ends of the steel cylinders, and the micrometer screws are turned till the convex end of the steel cylinders coming in contact with the end of the bar, the pointed end of each cylinder pressing against the steel plate attached to the axis of the level, turns the level, till the bubble rests nearly in the middle. The divisions of the head of the micrometer screws, and the divisions of the level scales at which the end of the bubbles rest, are then read off. The slides are now withdrawn through a small space, the carriage moved till the axes of the second bar coincide with the axes of the steel cylinders, and the micrometer screws turned as before, till the convex ends of the cylinders come in contact with the ends of the second bar, the conical points turn the level till the bubbles rest nearly in the middle of the scale, the divisions of the heads of the micrometer screws and divisions at which the ends of the bubbles of level rest are read off. This constitutes one comparison.

After a certain number of comparisons have been made in this manner, each bar is turned, so that the surface which was undermost becomes uppermost, without turning either of them end for end, and the same number of comparisons made as in their original position. The object of this is to estimate any error that might arise in making the ends of the bars coincide with the axes of the two steel cylinders, supposing the plane end of the bars not to be exactly at right angles to the axes. During the comparisons the bars are covered by a wooden case, which allows the heads of the micrometer screws and tubes of the levels to be seen, and has two openings, covered with glass for observing the thermometers placed on the bars to be compared.

The delicacy of this "comparateur" is such that unless extraordinary precautions are taken, the errors produced by the fluctuations of atmospheric temperature are much greater than the errors of measurement.

In order to eliminate error, arising from the heat radiating from the observer, Bessel recommends calling the bars A and B; A should be brought between the micrometers, then B, B again, and then A. These four measures he calls one comparison. The observer then should station himself on the other side of the comparateur, and make a second comparison. Bessel made a number of comparisons of two bars in a cellar, where the change of temperature was very small.

The means of four comparisons, two before and two after, the bars were turned, differed from the mean of fourteen sets of 1 inch from comparisons by the following fractions of a line:—

− 0·00010
− 0·00010
− 0·00003
+ 0·00013
− 0·00001
+ 0·00010
+ 0·00002
− 0·00002
− 0·00011
− 0·00018
+ 0·00011
+ 0·00009
+ 0·00007
0·00000

To make the axes of the bars coincident with the common axis of the steel cylinders a ring carrying a fühlhebel (lever of contact) can be fastened on the end of either cylinder. Bring the fühlhebel in contact with that portion of the end of the bar which is cylindrical, and turn the cylinders round its axis. If the long arm of the fühlhebel remains pointing to the same division of the arc, along which it moves, the end of the bar is strictly centred, if not the long end of the lever will move on the graduated arc.* A Prize Medal was awarded to Mr. Baumann.

SIMMS (No. 741) exhibits the three standard yards, prepared for Her Majesty's Commissioners, for the restoration of the standard of length, with two methods of supporting them, one by Professor Miller, consisting of a system of levers, by which an equal degree of pressure is sustained upon eight equidistant points of the bar; the second by the Rev. R. Sheepshanks, by floating the bar in mercury, which is therefore equally supported at every point throughout its length; the bar is covered with a coating of gold-beater's skin to defend it from attack by the mercury. It is probable that the former is the better method, as the latter, though good in theory, is probably not good in practice, from the fact that iron rusts easily in mercury, and copper and its alloys combine easily with it.

Mr. Simms also exhibits two standard scales, which have been used for the formation of many scales now in use. They were made by the exhibitor, whose property they are. The tubular scale is No. 3 of Mr. Bailey's Report on Standard Measures.†

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* For a complete description of this instrument, see Bessel's Darstellung der Untersuchungen and Maassregeln, &c., Berlin, 1839.

† See the Transactions of the Royal Astronomical Society.

Dividing Machines.

ACKLAND (No. 368) has exhibited a machine for dividing hydrometers and other variable scales, with accuracy. The instrument is furnished with a mounted head, screw, and suitable cutting apparatus.

The usual means of graduating hygrometers is by determining three points by means of three different fluids, whose specific gravities are known, and dividing the intervals between these points into equal parts. This method is evidently defective, as the divisions, instead of being equal, increase in a given ratio from below upwards.

The plan adopted by Mr. Ackland may be divided into three processes :—

1st. The ascertaining the exact position of three or more points of the scale according as the stem of the hydrometer is more or less cylindrical.

2ndly. The dividing with great accuracy a scale on box-wood, to show the specific gravities required to be indicated by the hydrometer, and to be used by the instrument for the purpose of measuring and correctly marking the distance of one division from another on the paper scale with true mathematical certainty.

3rdly. The making a reduced copy of the box-wood scale, so as to form a scale, the points of which shall correspond with the distance between the ascertained points of the hydrometer bulb. The scale so formed on paper is the scale for the hydrometer. For example, suppose it be required for a hydrometer to show specific gravities from 1·000 to 0·700 : to show this, a bulb is chosen with a stem as uniform as possible, and three points, viz., ·700, ·850, and 1·000 are ascertained as follows :—

Let a b c be the degrees required. Suppose m be the point on the stem whereon it is required to mark the highest specific gravity, viz., 1·000 = a. To find this point, the instrument is loaded until it floats in distilled water at the temperature 62 Fahr., at the point m ; let the weight of the instrument then be x.

To find ·850 = 6.

Load the instrument until it weighs $\frac{a\,x}{b}$, where it floats in distilled water, mark the tube at n.

To find ·700 = c.

Load the instrument until it weighs $\frac{a\,x}{e}$, where it floats in distilled water, mark the tube o.

Finally, before sealing the instrument, make it weigh $a\,x$; then $m\,n\,o$ will respectively represent the specific gravities required. By this plan, which was suggested to Mr. Ackland by Dr. Clark of Aberdeen, the correct position on the stem of the three specific gravities is obtained ; the next and most important operation is the subdivision of these spaces so that each division shall be in its true position. This is done by copying a calculated scale by aid of the machine, the construction of which is such that a proportionate scale of any length less than the original can very readily be produced.

The scale is determined by forming a table of the reciprocal of the specific gravities, and taking the differences between them ; in use the micrometer head is successively advanced, and each division is cut with accuracy and with great rapidity.

Most of the scales of the hydrometers exhibited have been graduated in the usual way, and are therefore inaccurate; those exhibited by Griffin (No. 457), were performed by this machine, which Mr. Ackland has the merit of inventing. He is the first in England who has carried into active practice a correct mode of subdividing glass vessels for gases and liquids by the aid of a machine.

The cutter is made to cut, and cuts a division. The detent, apparently, is then brought back to the common centre of the helix screw, either by lifting, unclamping and reclamping, or in some equivalent way, and runs its course again to bring the cutter ready for another cut, and so on. There is also a second novelty, viz., a neat little contrivance to make every fifth division longer than the rest by means of a wheel which advances one step at each division or movement of the cutter frame. A point let drop to touch its circumference, determines, by the depth to which it descends, the length of the cut; but at every fifth step the wheel has a notch into which the point descends, allowing the cutter to make a longer stroke, longer by the depth of the notch.

A Prize Medal was awarded to Mr. Ackland.

PERREAUX (France, No. 369) has exhibited a straight-line divider. This is a beautifully-contrived divider on Ramsden's principle, with a long fine steel screw. The novelties are, first, the wheel at the screw-head, which is divided into 400 parts, and has cut upon its circumference (which is made broad) a helix screw, in the thread of which runs a detent, carried along by the run of the thread till it meets a stop clamped on the helix at a definite point. This arrests the screw, at this point of the motion. A Prize Medal was awarded to M. Perreaux.

FROMENT (France, No. 1609) exhibits a divided metre, the divisions on which are beautifully distinct, and as far as could be ascertained very exact. It is believed that the divisions were cut by M. Froment's dividing engine, which he has constructed for dividing astronomical and geodetical instruments. M. Froment has also constructed a screw more than a metre in length, for the purpose of dividing lines quickly, and it is understood that in so doing electricity is made use of in connection with the movements of the screw and machine.

A Council Medal was awarded to M. Froment.

The CONSERVATOIRES DES ARTS ET MÉTIERS (France, No. 1568) exhibit a brass metre by Gambey, decimally divided. Also a fine platina metre, which is described as the "second type of the Collection of Weights and Measures of the Conservatoire des Arts et Métiers, executed by M. Brunnen and compared by M. Silbermann," and is stated to be a copy of the ancient platina metre of the same collection, an immediate derivative of the prototype of the archives of France, and to be longer than that of which it is an immediate copy, by 0·000019 millemetre.

It is properly speaking a "metre à bouts," and is converted into one "à traits" by attaching to each of its extremities a supplementary piece of platina, separated from the bar by a very thin lamina of gold, which appears as a fine line of gold at the junction. It is supported on a bed of bronze, to which it is attached firmly and by accurate adjustment at one end, whilst the other is left free to slide by expansion; thus converting the whole system into a Borda's pyrometer, the amount of relative expansion being read upon a scale, the value of whose points have been derived from experiment by immersion in melting ice and boiling water.

The Conservatoire des Arts et Métiers also exhibits a standard kilogramme and litre; a series of French coins of legal currency, and a collection of wood measuring rods, both in single lengths, and in more or less numerous joints; also measuring chains, and a series of measures of capacity of the following values (in litres), viz. :—

20, 10, 2, 1, $\frac{1}{2}$, $\frac{2}{10}$, $\frac{1}{10}$, $\frac{1}{20}$, $\frac{2}{100}$, $\frac{1}{100}$, $\frac{1}{200}$, in brass, with ground rims and sliding glasses to each.

Balances.

The Exhibition contains balances of all sizes, from Mr. Fox's balance, intended to carry extremely small weights, up to the balances of L. Oertling and the American balance, both of which are capable of carrying 56 lbs. in each pan. Many of them have probably never been surpassed in the construction of the beam. knife-edges, planes opposed to them, permanence of the adjustments, and beauty of workmanship; yet in all, the position of the beam, when loaded with the weights to be compared, is shown by a long index nearly in contact with a graduated arc, although for several years other and greatly superior methods of determining the position of the beam have been in use—such as by a graduated arc attached to one end of the beam, and viewed through a compound microscope having a horizontal wire in the focus of the eye-glass, or by a mirror attached to the beam, in which the reflected image of a scale is viewed through a telescope.

In the balances exhibited the beam and pans are suspended on knife-edges, more or less in length, with the single exception of Mr. Fox's balance, in which the beam has pivots, the conical ends of which play in hollow agate cones of larger angle.

There is no example of the balances constructed under the direction of Gauss and Weber and described in the "Göttingen Transactions," in which the beam is suspended by two watch-springs, and each pan by a single watch-spring; nor of either of Steinheil's balances, in which the beam and pans are suspended by wires or silk ribbons; nor of the balances first (Professor Miller believes) invented by Steinheil and used by Kupffer in comparing the Russian standard of weights, in which the beam carries two small steel spheres in the middle, resting upon a steel plane, and a sphere at either end, upon which rest the plane or slightly-concave spherical surfaces of the plates from which the scale-pans are suspended.*

There are a variety of contrivances for checking the oscillation of the beam and pans when in action: none of them can compare in simplicity and efficiency with the apparatus invented by Wollaston, and used by the late T. C. Robinson, Barrow, Dover, and by most of the English makers of balances, and also by Nissen, of Copenhagen, the only foreign maker who appears to have made use of it.

In nearly, perhaps in every instance, when the divisions of the scale, to which the index of the balance points, were numbered; the division to which the index points when the beam is horizontal is marked zero, and the scale numbered 1, 2, 3, &c., to the right and left. This method is most inconvenient, and frequently leads to error. The number of the divisions ought to run all the same way, and need not begin with zero, it being far better to number that division to

* See Kupffer's work on the Comparison of Standards for a description of this balance.

which the index points, when the beam is horizontal, 10, 20, or some multiple of 10, for the purpose of avoiding the trouble, perplexity, and liability to error, attendant upon the necessity of noting numbers, in addition to whether the numbers are positive or negative. This remark is of general application to all instruments to which scales are affixed.

L. OERTLING (No. 334) exhibits a large balance having a beam 3 feet in length, coated with platinum,* and capable of carrying 56 lbs. (equal to 25·4 kilogrammes) in each pan. The beam, a pierced rhomb, is constructed so as to give great strength in proportion to its weight. Any tendency to lateral yielding is counteracted by casting the beam with edge bars.

The whole length of the middle knife-edge rests upon a plane surface of steel: the three knife-edges are long. Plane surfaces of steel, from which the scale-pans are suspended, rest upon the extreme knife-edges. When not in action the beam and the steel planes from which the scale-pans hang are supported, so as not to be in contact with each other. The frame for supporting the beam and pans is extremely well contrived; so also is the mechanism for lifting it.

He exhibits also a balance capable of carrying one kilogramme in each pan. The beam of this balance, which is 16 inches long, is coated with palladium;† the three knife-edges, as well as the plane upon which the middle knife-edge rests, and the planes from which the pans are suspended, are of agate, so that the whole instrument is unaffected by acid vapours. The beam is graduated, and small differences of weight are determined by a small weight that can be placed upon parts of the graduated beam. The beam and pans are supported, excepting when in action. The adjustments of the knife-edges, in the direction of the length of the beam, are as few as possible to be very permanent. The knife-edges are not capable of any adjustment after leaving the artist's hands in a direction perpendicular to the length of the beam. As far as the beam and knife-edges are concerned, a better balance has probably never been constructed. He exhibits also a smaller balance: the beam is 14 inches long, similar to the former in construction, and capable of carrying about 1,000 grains. A Council Medal was awarded to Mr. Oertling.

DOVER (No. 344) exhibits a balance, which in construction is similar to the balances constructed by the late T. C. Robinson, and, in execution, fully equal to the balances made by that most excellent artist. The beam is 10½ inches long, and is capable of carrying about 2,000 grammes in each pan.† The three knife-edges are of steel, the planes opposed to them being made of agate. The final adjustments, both in the direction of the length of the beam and in a direction perpendicular to it, are effected by a cut at each end of the beam making an angle of about 45° with the axis of the beam, which may be widened by means of a screw. This is an excellent mode of adjustment, succeeding perfectly and proved to be very permanent when confined to extremely narrow limits. If these limits

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* These beams were coated by T. H. Henry Esq., F.R.S., by a peculiar process, in which the electric current was employed in depositing these metals. It would seem, from this successful application, that the same process is applicable to graduated instruments.

† A similar balance, finished by Mr. Dover, was used repeatedly by Professor Miller to weigh 5,760 grains, and was not in the slightest degree injured.

be exceeded, as they sometimes are in unskilful hands, the end of the beam is cracked and destroyed.

Mr. Dover has substituted chains with long links for silk threads, for suspending the pans, and has added an ingenious contrivance for supporting glass tubes in weighing.

A Prize Medal was awarded to Mr. Dover.

Fox (No. 377) exhibits a balance for extremely small weights, which has, instead of a knife-edge at the middle, an axle ending in conical points, which points play in conical holes (the angle of the cone in the holes is, of course, greater than the angle of the cone of the pivots). The attraction of a magnet brings the beam exactly to zero before weighing. In order to overcome the friction, of which much is introduced by the construction of the balance, there is an instrument for rasping on the case.

Marriott (No. 341) exhibits a chemical balance, the beam of which, made of fir, is a wide bit of wood, with interstices cut out so as to leave a strongly-framed network. The knife-edges do not appear to admit of any adjustment. The scale-pans are suspended from double hooks of wire hanging on the end of the knife-edges. This instrument is a curiosity: it is stated by the maker to be sensible to the 100th of a grain. It is a good example of a make-shift for a balance, when at a distance from good workmen.

De Grave, Short, and Fanner (No. 333) exhibit two assay-balances, apparently of very good workmanship, but not adjusted,* and a large number of commercial balances of various kinds, weights, and measures of capacity and length.

Bache (United States, No. 395a). Large balance, capable of carrying 56 lbs. (equal to 25·4 kilogrammes) in each pan. The knife-edges are square bars of steel. Each bar is fitted into a socket attached to the beam, having a rectangular notch, so that any one of the four edges of the bar may be used as a knife-edge.† The socket, in which one of the extreme knife-edges is fixed, moves in a slit in the direction of the length of the beam, and is adjusted in that direction by means of two screws.

A smaller balance is exhibited, of almost exactly the same construction as the preceding: it is capable (probably) of carrying a kilogramme in each pan. A Prize Medal was awarded to Mr. Bache.

Deleuil (France, No. 160) exhibits a large balance, capable of carrying two kilogrammes in each pan. The middle knife-edge rests upon a plane surface of steel. The pans are suspended from plane surfaces of steel, which rest upon the extreme knife-edge. Screw adjustments appear to be avoided, in order to secure invariability in the positions of the knife-edges. The cast-iron base of the balance has holes under the extreme knife-edges, for suspending large globes of glass for weighing gases, in an inclosed space beneath the base of the balance. Both the construction and workmanship of this balance appear to be extremely good.

A chemical balance, by the same exhibitor, capable of carrying 300 grammes in each pan. The pans are of platinum, suspended by silver wires.

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* The centre of gravity is too high to admit of using them.

† In the event of one of the edges being damaged this arrangement is of great service.

Another chemical balance, capable of carrying 200 grammes in each pan; the pans are of platinum.

In these two balances the middle knife-edge rests upon a plane surface of steel. The pans are suspended from slightly-curved steel hooks.

Balances of this construction, though considerably inferior to that in which the pans are suspended from plane surfaces, are simple, not easily deranged, and accurate enough for all the ordinary purposes of chemistry, for which they are expressly constructed.

An assay-balance, of the ordinary construction and excellent workmanship, is also from the same exhibitor.

A Council Medal was awarded to M. Deleuil.

COLLOT BROTHERS (France, No. 1155) exhibit a large balance, capable of carrying two kilogrammes in each pan. In its construction and excellence of execution, it very closely resembles the large balance of M. Deleuil.

An assay-balance of the ordinary construction is also exhibited by Messrs. Collot.

A Prize Medal was awarded to Messrs. Collot.

BÉRANGER (France, No. 761) exhibits a balance to be placed upon a counter, with platforms for holding the substance to be weighed, and the weights. With fifty kilogrammes in each pan, the addition of one gramme to the weights in either pan causes the index to move through about a quarter of an inch. When tried with twenty kilogrammes in each pan it was found to turn very sensibly on placing half a gramme in one of the pans.

M. Béranger also exhibits a steelyard in which the weight is moved along the arm by a screw of the length of the long arm, and parallel to it, having a head of about 4 inches diameter, divided into 100 parts. This steelyard is sensible to 100 grammes, with 1,000 kilogrammes suspended from the short arm.

Also, *bascule en l'air*, a double steelyard. The end of the short arm of a steelyard is connected by a link with the extremity of a lever, and at a distance from the fulcrum of the lever, equal to a small fraction of its length, is a knife-edge from which the substance to be weighed is suspended. One of these, capable of weighing 1,000 kilogrammes, costs 260 francs.

M. Béranger exhibits a model of a machine for determining the pressure exerted by each wheel of a locomotive.

Also, a *peso-compteur*, a weighing-machine, which registers on a sheet of paper the weight of every article weighed. Besides these there are a great many commercial balances, all of which are most ingeniously contrived, extremely well made, very accurate, and considering the workmanship and the number of adjustments to be attended to, very cheap. Although the Jury considered them well deserving such reward, no Medal was voted to M. Béranger, on account of these being commercial balances, and as such thought by the Jury to belong to instruments for direct use, rather than to philosophical instruments: they have, however, received a prize in Class V.

SACRÉ (Belgium, No. 504) exhibits a large balance, capable of carrying two kilogrammes in each pan. The manner of fixing the extreme knife-edges to the beam is different from that usually adopted, in which the under horizontal surface of the knife-edge is in juxtaposition with the horizontal surface of the beam, widened at that particular part, and firmly fixed to it by one or more screws.

In M. Sacré's balance, on the contrary, the ends of the beam terminate in vertical plane surfaces, to which are attached, by screws, vertical plates of steel, terminating above in knife-edges. The pans are suspended in such manner, that their swinging in any direction has no tendency to twist the beam of the balance.

This instrument is remarkable for the extreme beauty of its workmanship.

M. Sacré also exhibits an assay-balance, in which, contrary to the usual construction, the pans are suspended from plane surfaces of steel which rest upon long knife-edges, and are supported independently of the beam when the balance is not in action: it is therefore not only more accurate than ordinary assay-balances, but is enabled to carry 20 grammes in each pan without injury. The work is extremely good.

In assay-balances, as usually constructed, the pans are suspended from hooks, which themselves rest on hooks worked to a fine edge, attached to the ends of the beam, and are not calculated to carry a weight of more than two grammes.

A Prize Medal was awarded to M. Sacré.

A. OERTLING (Prussia, No. 87) exhibits a balance of very beautiful workmanship, capable of carrying a kilogramme in each pan.

The knife-edges are let into dovetailed notches in the beam.* The adjustment of the distance of the extreme knife-edge from the middle knife-edge is effected by means of a vertical cut in the metal of the beam, which may be slightly widened or contracted by screws. The agates which rest upon the extreme knife-edges, and from which the pans are suspended, are *not* plane, but have an obtuse re-entering angle, into which the less obtuse angle of the knife-edge enters, and are not suspended independently of the beam when the balance is not in action.† Two thermometers are placed with the bulbs as high as the beam; but it probably would have been better if the bulbs had been placed a little above the scale-pans, for the temperature of the air immediately surrounding the object to be weighed often differs sensibly from that of the air in the upper part of the balance-case.

Oertling has also two smaller balances, of similar construction, capable of carrying 100 grammes in each pan. A Prize Medal was awarded to Mr. Oertling.

REIMANN (Prussia, No. 86.) Balance, capable of carrying one kilogramme in each pan. The knife-edges are opposed to agate planes. The adjustment of the position of the knife-edges is effected by means of an oblique cut at each end of the beam, the breadth of which may either be increased or diminished by screws.‡ This is the only balance in the Exhibition in which a circular level has been adopted. The Jury considered it worthy of Honourable Mention.

HOFFMANN and EBERHARDT (Prussia, No. 88) have exhibited balances for apothecaries; they seem well suited to the purpose they are intended to serve.

LUHME, J. F., and Co. (Prussia, No. 83), exhibit chemical balances. One of them is capable of carrying one kilogramme in each pan; another of carrying

* It is doubtful whether this mode of attaching the knife-edge is quite as good as when the beam is made wider at the extremities and the middle, and the whole length of the knife-edge rests upon it.

† The form of the agates seems to be objectionable.

‡ In the present case, too much reliance seems to have been placed on this mode of adjustment; for one of the cuts has been widened by screwing till a crack in the beam has begun to form.

100 grammes in each pan; a third 50 grammes in each pan; and a fourth 25 grammes in each pan.

A Prize Medal was awarded to Messrs. Luhme.

Batka (Austria, No. 135) exhibits a very small balance by Kusche, of Vienna, contained in a platinum blowpipe apparatus. It is very well made, and the Jury deemed it worthy of Honourable Mention.

Dolberg (Mecklenburg Schwerin). Balance, to carry one kilogramme in each pan. This balance is in many respects very well constructed: but the middle knife-edge is supported by two agate planes, and the bearings of the knife-edge on the planes are rather short, both of which circumstances are defects. The oscillation of the pans is checked by hair brushes, which on turning a handle ascend till the ends of the brushes touch the under sides of the pan: in this arrangement there is reason to apprehend that loose hairs might attach themselves to the under sides of the pans, and so lead to an error in the weighing.* The pans are suspended from plates of steel, having plane surfaces which rest upon the extreme knife-edges.

A Prize Medal was awarded to Mr. Dolberg.

Becker (Netherlands, No. 83). Balance, capable of carrying one kilogramme in each pan. The beam is a single bar, the middle knife-edge being supported on two agate planes.† The contrivance for lifting the pans and beam when not in action is ingenious, inasmuch as the motion is slow at the time the beam is deposited on the middle support, and he agate planes from which the pans hang on the knife-edges, but it is unsteady in a lateral direction; but there is reason to apprehend the extreme knife-edges would not touch the agate planes in the same parts in successive weighings. The method of attaching the pans to the brass rods by which they are suspended, in such a manner as effectually to guard against upsetting the pans wherever the weight may be deposited, is extremely simple and ingenious. The Jury considered it worthy of Honourable Mention.

Nissen (Denmark, No. 20). A large balance to carry 10 lbs. (4·54 kilogrammes): the middle knife-edge is cut away in the middle, so that the bearings of the edge on the middle plate are too short. The pans are suspended from plates having concave surfaces, which form of plate is objectionable. They are not supported independently of the beam, when the balance is not in action.

The excentric motion for putting the balance in action had been injured, so that it could not be tried.

A small balance exhibited by Nissen, capable of carrying more than 100 grammes. The middle knife-edge in this also is cut away, so that the ends only touch the plane surface on which it rests. The balance in other respects resembles Robinson's balances, except that the middle knife-edge rests upon two planes, and that the plane surfaces are of steel instead of agate. It is furnished with Wollaston's contrivance for checking the oscillation of the pans and beam.

The same exhibitor has also a small assay-balance.

The Jury considered Mr. Nissen as deserving Honourable Mention.

Littman (Sweden, No. 15). In this balance the index is at one end of the

* This contrivance is greatly inferior to Wollaston's for effecting the same purpose.

† This is not a good construction.

beam. In addition to this index there is another pointing upwards, the end of which is viewed through a compound microscope, having a divided scale or glass in the focus of the eye-piece. This contrivance for reading off the extreme portions of the balance during its oscillation is far inferior to a graduated scale attached to the beam of the balance, observed with a compound microscope having a single wire in the focus of the eye-piece. It also adds greatly to the bulk of the balance-case. The Jury considered this balance deserving Honourable Mention.

VIBERG (Sweden and Norway, No. 14) exhibits a chemist's balance, which the Jury considered worthy of Honourable Mention, it being well adapted for the purposes it has to perform.

Coin-weighing Machines.

We will now turn our attention to another class of balance, recently introduced, viz., coin-weighing machines. Of these there are three in the Exhibition—one exhibited by — COTTON, Esq., Governor of the Bank of England, a second by Captain SMITH, and a third made by DELEUIL (France, No. 160): this last instrument was designed by Baron SEGUIER.

Before proceeding to the particulars of these beautiful instruments, it may be well for a short time to dwell upon the want which has called them into existence, as kindly explained by William Miller, Esq., of the Bank of England. All sovereigns brought into the Bank of England by the public are weighed singly, and this is found to be absolutely necessary, else the stock of sovereigns in the Bank would very soon fall below the legal current weight of 122½ grains each. The Bank, therefore, is compelled to weigh all the gold coin it receives singly, to guard against loss.

In June, 1842, the Queen's Proclamation was issued, commanding all persons to cut and deface whatever gold coin was found to be below the current weight. Before that time the light sovereigns, though they were rejected by the Bank, were accepted almost everywhere for their full value, and the public were not disposed to criticise very nicely the Bank's weighing, as the rejection of their money occasionally, when it was really of the current weight, or the issuing it to them a trifle below the weight, was of small consequence; for though it might occasion a little trouble, it entailed no loss. But it was quite a different affair when their sovereigns were cut, as well as rejected, so that they were obliged to sell them as bullion, sometimes at a loss of threepence or fourpence a-piece; or when, as was sometimes the case, they received sovereigns at one counter of the Bank, which were cut and returned to them when tendered at another. The public then, as might be expected, were very angry, but there was no help for it. The Bank had provided the best scales that could be procured: they had the most experienced weighers: they re-weighed singly every gold coin in their stock, amounting to upwards of £8,000,000, and weeded it of all the light that could be detected, at a loss of between £3,500 and £4,000; but the evil remained. Sovereigns were still issued at one counter which were rejected and cut at another.

This did not arise from any fault either of the Bank or of its officers, but from the inherent difficulties in the operation of weighing so accurately as was necessary, or with the same result, in a limited time, even with the best-constructed scales. Some of the causes of error Mr. Cotton ascertained to be, differences in the weights made (notwithstanding the Mint stamp attached to them), of considerable amount in relation to the degree of correctness required; currents of air acting unequally upon the scale-pans; a constant diminution of the weight of one pan, by the act of placing and displacing the coins to be weighed, by which the equipoise was every moment destroyed; the striking of the scale-pans upon the counter; difference in the judgment of the weighers; the short time which could be allowed for the operation; failing of the eye-sight, flagging of the attention, and sleepiness from the monotony of the employment; difference in the rate of vibration of the beams; defects of principle in the construction of the scales, to obviate which would have destroyed their simplicity and marred their general usefulness.

All these difficulties (and they were great) were overcome by Mr. Cotton's machine; and since the year 1844, out of the large number of 80,000,000 of pieces which have been weighed, not a single source of error has been made out against them. Some few sovereigns are still weighed as they are received from the public by the common scales, but such are never re-issued by the Bank until they have passed through the machines, which extract from them about two per cent. of lightness. The Bank sustains the loss upon these unavoidable errors, in preference to the loss of time, the trouble, and the vexation, which the re-issue of them as they were received from the public would occasion to all parties.

We now proceed to the description of Mr. Cotton's machine.

It consists of a square brass box: on the top is placed a hopper to hold the sovereigns to be weighed. This hopper is a long trough, placed at an angle of about 45° with the top of the box: it will hold about 500 sovereigns. In front of the box are two small apertures, to which are fitted two receivers, one for the sovereigns of full weight, the other for those which are light.

Inside the box, and near the upper plate, the beam or balance is placed, at one end of the beam, and above it is poised upon a knife-edge, a small platform, which receives the sovereigns to be weighed. This platform, which, in fact, is one of the scales, is kept in its position by means of a small pendulum, on which, at about an inch below the platform, there is an oblong perforation, about half an inch in length, technically called a slot, in which a small ivory rod works freely up and down without touching the sides.

Between the slot and the platform a pair of forceps is placed. From a knife-edge at the other end of the beam a small round polished plate is suspended, to which a pendulum is fixed, and at its lower part the scale is placed to receive the weight. Above the small round plate, under the top of the box, is fixed an agate with a blunt point. When the machine is in motion the small ivory rod is depressed: this, on touching the bottom of the slot, or opening in the pendulum in which it works, brings down the beam on that side, and raises it, of course, on the other, the weight side, until the small round plate on that side touches the agate point. The beam is then in a horizontal position. As soon as this is effected the forceps catch hold of the pendulum between the platform and the slot, and hold it firmly. The balance is then in a condition to receive the sovereign, which is shifted from the bottom of the pile in the hopper, and brought by means of a slide along a channel, just large enough for a sovereign of the proper standard gold to pass but not large enough to admit a counterfeit, and deposited upon the platform. The forceps then let go their hold, the ivory rod is gently raised, and if the sovereign happens to be light that end of the beam rises, and the other end leaves the agate point; but if the sovereign be full weight, the beam remains stationary, and the small plate on the weight end is in contact with the agate point.

When the sovereign is weighed the operation of its removal is very ingenious, and is as follows:—Two bolts are placed at right angles to each other, and on each side of the platform or scale there is a part cut away, to admit of the bolts striking so far into the area of the platform as to remove anything that would nearly fill it. These bolts are made to strike at different elevations, the lower one striking (as to time) a little before the other. If the sovereign be full weight the scale remains down, and the lower bolt knocks it off into the full-weight box. If the sovereign, on the other hand, be light, it rises up, the first bolt strikes under and misses it, and the higher bolt then strikes and knocks it off into the light box. This machine weighs about thirty-three sovereigns in one minute. The weights used are of glass, and are adjusted to within the ten thousandth part of a grain.

It is understood that these machines, since they began to be used in 1844, have not cost £5 for repairs, and that they effect a saving in salaries alone of full £1,500 per annum, after deducting ten per cent. for the replacement of capital sunk in their establishment.

A Prize Medal was awarded to Mr. Cotton.

Smith (India) has exhibited a coin-weighing machine, which is an exceedingly ingenious application of that of the areaometer or hydrostatic balance. The counterpoise to the point weight of the scale-pan and coin is made to rise and fall in a cylinder of water, the oscillation being deadened by a circular plate forming part of the counterpoise wholly immersed in the fluid, and of such an area as to afford considerable resistance to the rising or sinking motion. By a proper adjustment of the diameter of that portion of the counterpoise which is partly beneath and partly above water, and of the length of the lever arm which carries the scale-pan, a given deviation in the weight of the coin one way or other from its legal weight may be made to correspond with a given depression or elevation of the counterpoise, and therefore of the scale-pan, below or above a certain medium or zero position, the scale resting at a level, corresponding to the amount of excess or defect of the coin above or below the standard.

At levels corresponding to half-grains of difference of weight, shelves are placed which receive the coins from the scale-pan, according as, on arriving at its point of equilibrium, it happens to be opposite to the interval between either shelf and the next above it, and once thrown upon that shelf it glides down and finds its way into a receptacle corresponding by an appropriate passage. Thus the coins enter twelve panels, differing each by twelve grains of weight.

To throw the coin off the scale upon its proper shelf, the scale-pan is peculiarly constructed of wire, horizontally laid, so as to allow a scraper also of wire, vertically arranged, to pass between and beside the framework of the pan, and being pushed along, at the end of each weighing, the coin is shoved by it off the pan upon the shelf. The pan-frame thus lightened rises to the proper position for receiving another coin, which is placed on it by a feeding-pipe in the manner usual in coining processes.

Any number of small weighing-machines may be mounted side by side so as to occupy a very moderate compass, and may be worked simultaneously by a common feeding and a common discharging movement, and all may be made to discharge their contents on the same shelves conducting to common receptacles.* A Prize Medal was awarded to Captain Smith.

DELEUIL (France, No. 160) exhibits a beautiful coin-weighing machine, invented by Baron Seguier, Membre de l'Académie des Sciences, differing, however, from those above described in its mechanical arrangements, and in some particulars of construction which are necessary to its performance of the additional operation required by the French Bank.

In the Bank of France each piece of money is weighed in a small balance especially constructed for the purpose, by men charged with this particular duty. The beautiful coin-weighing machine in question is designed to supersede this work by mechanical means. In its operation it exhibits quickness and regularity in performing the operation of distributing the pieces into three classes, those which are heavy, those which are of exact weight, and those which are light.

The instrument is distinguished in its operations from Mr. Cotton's, in thus distributing the pieces into three classes, which Mr. Cotton's does in two only, such being necessary in the Bank of France, though not required in England.

The right to this elegant invention not being secured by a patent, its internal construction could not be examined, but so far as could be judged from the working it, as exhibited, the principle seems to be the making available the declination of the index of the balance, or light steel rod, to the right or left of the vertical, according to the excess of weight in either pan, to give motion to one or other of two light brass plates *in the act* of raising the balance. The force so applied being, not the mere difference of weights between the scales, but an external power applied through this medium. The motion thus given to the brass plate being conveyed downwards by an appropriate train of mechanism might easily be applied to an interposed obstacle or otherwise. The coin on its delivery from the scale, is diverted from that passage which it would have followed had the index remained vertical, into one of two other channels, according to the inclination of the index.

The machine is fed by a hopper, the coin being thrown promiscuously in. To prevent its jamming, and refusing to pass, it is constantly stirred from below upwards by a wheel set round with steel pins so as to disturb the self-arrangement of the coins in the hopper, and let them fall over one by one into the feeding-trough. It is understood that about fifty coins could be weighed per minute by a double machine such as that exhibited. The working appeared to be not quite continuous, but in all other respects perfectly satisfactory, the interruption to the regular delivery of the coins being little more than momentary.

It will be understood that for the reason above assigned, this account of its operation is merely conjectural. Sir John Herschel remarks that it would be

* A full description of this ingenious mechanism, which was contrived and executed for the Madras Mint under Captain Smith's direction, will be found in the "Professional Papers of the Madras Engineers," vol. ii.

easy to devise a machine for a similar purpose, founded on the principles, *first*, of preventing the descent of either scale, unless the excess of weight in it surpassed the legal "remedy," and allowance for wear and original error, which might be done, by giving each end of the beam a support from below equal to the remedy, but rising only on its descent; and, secondly, by presenting in the closest proximity to the under side of the beam, but not in actual contact, the extremity of a conducting rod of copper, completing a galvanic circuit through the beam and its central steel knife-edge resting on a steel plane, and thus animating one or other of two electro-magnets, which by its attraction on a soft iron bar should shift either the point of delivering or the point of reception of the descending coins, on their egress from the scale. The circuit being completed, the right-hand conductor would thus deviate the coins into receptacles of heavy, and that on the left into that of light coins, while a state of rest of the beam, corresponding to any excess *within the remedy*, either way, would cause no deviation, but allow the coins to fall straight into the middle receptacle. This description might enable any mechanist to construct such a machine, probably at small cost, and without infringing any patent right.

It is highly satisfactory to find an instrument of such high importance as the balance so well represented in the Exhibition; and when it is considered, in order to have a balance as perfect as possible, how very many circumstances are to be attended to, it must be deemed highly honourable to the exhibitors of good balances to have produced instruments standing the test of the rigorous examination to which they have been subjected. We observe, however, in the Exhibition, no self-weighing balances for small weights (up to 1,000 grains), on the principle of Marriott's spring-balance for large ones, or on that of the simple extension of a long spiral spring, which is a very convenient form of instrument when great accuracy is of less consequence than expedition.

Air-pumps.

Most of the important facts which we know relative to the properties of air may be said to have been elicited by the employment of the air-pump. It is satisfactory to find that the Exhibition contains instruments of a new and improved construction; but it is matter of regret that so small a number of manufacturers have contributed.

The air-pumps most commonly used are made either with brass stopcocks, or with valves of oiled silk or leather. The former, when properly constructed, and new, generally act well, by exhausting the air thoroughly; but after having been in use for some time, they become less accurate than those furnished with valves, after an equal amount of wear. But the valves themselves are also imperfect, owing to the pressure of the external air on that within the piston preventing the latter from rising when the air is almost exhausted. Attempts to overcome this difficulty have been made in the pumps exhibited, some of which are very superior in their action, and have probably never been surpassed.

The exhibitor of the best air-pump is NEWMAN (No. 674). This has a ground glass plate, to avoid injury from sulphuric acid. It has two pumps with metal valves: on one of these are two barrels, open at the top to the atmosphere, as in the common table air-pump: this arrangement exhausts the receiver quickly, but on account of the nature of the valves, not beyond 0·4 inch or 0·5 inch of mercurial pressure. The other pump has a single barrel, with an oil cistern at the upper part, the air being lifted through a valve at the bottom of this cistern. If anything re-enters the barrel, it can only be oil, which is brought out with the air at the next up-stroke of the piston. The piston has a metal valve; but the opening of this valve is not necessary to the continuation of the exhaustion, as the piston at its lowest point passes below the aperture leading to the receiver. This construction of air-pump exhausts more thoroughly than any yet known.

In the experiments which were tried, the reading of the barometer at the time being 30·08 inches, the gauge of the air-pump stood at 30·06 inches. A Council Medal was awarded to Mr. Newman for this air-pump.

WATKINS and HILL (No. 659) exhibit a new double-barrelled air-pump, on a plan suggested by Mr. Grove. It has oiled silk valves, and is so constructed as to leave the least possible residue of air in the barrel, after each stroke of the piston. The piston is solid, without a valve, and the shape of its lower part is an obtuse cone: part of this cone rises at the top of each stroke above the aperture leading to the receiver, and the air which has entered the barrel is, by the down stroke, forced through a valve at the apex of the hollow cone which terminates the lower end of the barrel, to which the lower end of the piston fits very accurately. The piston-rods pass through air-tight leather collars in the tops of the barrels. This pump exhausted the air till the elastic force was only 0·05 inch of mercury. A Prize Medal was voted to Messrs. Watkins and Hill.

KNIGHT and SONS (No. 453) exhibit an air-pump on Siemen's patent. It consists of two cylinders, of different diameters, the smaller one placed below the larger, and separated from it by a plate forming the bottom of the upper and the top of the lower cylinder. A piston-rod common to both cylinders passes through a stuffing-box in the plate, attached to which are two valved-pistons, working in their respective cylinders. The advantage of this construction is that the pressure of the external air on the oiled silk valve of the larger cylinder is taken off by the vacuum formed in the smaller one, and, in consequence, no greater resistance is offered by the valve than that arising from its adhesion and tension. The exhaustion of this pump is very rapid, and in the trial amounted to 0·24 inch of mercury.

VARLEY and SONS (No. 257) exhibit an air-pump upon a new construction. It is worked by a continuous rotatory motion of the handle; slide-valves being used to open and close the communication. On the piston arriving at one end to expel air from the barrel, it is followed by rarefied air from the receiver; the slide-valve closes upon the receiver, and connects the two sides of the piston; the residual air expands into the larger space, becomes equally rarefied, and the subsequent motion of the valves separates these spaces and connects the receiver with the closed end; the piston then returns to exhaust air into this end of the barrel and to expel it from the other, and thus continuous exhaustion is kept up, for, how rare soever the air becomes, it keeps flowing after the piston continually. The barrel is twice filled for every entire revolution of the handle. This pump has a single barrel with double action: it exhausts quickly, and the exhaustion was found to be 0·05 inch for a moment, but could not be maintained.

Varley and Sons also exhibit a second air-pump, smaller than the former: it has a double-acting barrel. The piston is worked by means of a crank and continuous circular motion of the handle.

Heywood (No. 404a). A rotary table air-pump, with self-opening valve worked by a crank motion. It acts with singular smoothness and ease.

Gogerty (No. 407) exhibits an air-pump of the common table form. It gave an exhaustion of 0·3 inch of mercury, which is considerable for this kind of air pump.

Ladd (No. 291a) exhibits an air-pump, which is single-barrelled and of a cheap construction, without any other claim to notice.

Yeates (No. 332) exhibits a double-acting air-pump of a cheap construction, which appears to be good for its price. Its valves are of oiled silk. The communication is in the middle of the barrel, a valve being placed there and at each end. Honourable Mention was awarded to Mr. Yeates.

Bryan (No. 408) has exhibited a double-action air-pump, constructed without valves and having a rotatory motion. The pump consists of a barrel, to which two smaller ones are attached on either side. In the large or prime barrel is a solid piston, which may be made to rise and fall at pleasure, and is attached to a piston-rod: in the centre of the secondary barrels are also small pistons, whose movements are simultaneous. Each rise and fall of the large piston is designed to draw off from the receiver 53 cubic inches of air, simply by its own elasticity. The double action, combined with the rotatory motion, has been introduced with a view to economise both time and labour, and the absence of the valves, to avoid the limitation of exhaustion attendant upon their use. This pump was not tried, in consequence of no one being in attendance on the Jury to explain its action, &c.

Breton (France, No. 1113) exhibits a double-barrelled air-pump. It has, instead of valves, a glass-plate sliding over apertures communicating with the receiver and the pumps. The motion of this glass-plate is produced by the mechanism which works the pump: it is very ingenious in its construction. The approximate exhaustion is first made by the ordinary alternate action of the barrels. The system of communication is then changed by shifting round the glass-plate, which serves as a valve during one-fourth of a revolution, when the rarefied air is condensed in one barrel and sucked into the other, whence it is ultimately ejected through a valve of oiled silk very close to the piston. On account of the distance between the pumps and the glass-plate, however small the pipe of communication, the exhaustion must be imperfect. The siphon gauge attached to the instrument indicated an elastic force of only one millimètre of a column of mercury; but a bubble of air was seen at the top of the mercury, proving its indication to be erroneous.

Deleuil (France, No. 160). This exhibitor has a double-glass barrelled air-pump, on M. Babinet's principle, the valves being opened by means of wires passing through the pistons. The opening of the valves is by this means rendered independent of the elastic force of the air remaining in the receiver. The degree of exhaustion which can be produced must depend on the air after the action of the piston. This appeared by the siphon gauge to be about one millimètre of mercury; but the top of the gauge could not be seen so as to ascertain whether any visible portion of air was there. In this pump, also, the vacuum is first approximately made by the alternate action of the barrels, after which one barrel exhausts the other by suction.

NISSEN (Denmark, No. 20) exhibits a double-acting single-barrelled air-pump, of an ingenious construction. This instrument only exhausted to 0·3 inch, as shown by the gauge, which was free from any visible speck of air. The Jury considered this pump as worthy of Honourable Mention.

Optical Instruments.

The telescope is an instrument of such high importance, that it ought to command at all times the unceasing attention of opticians, as directed to its improvement and the bringing it to the highest possible state of perfection. In the Exhibition, if we except those affixed to astronomical instruments, there are but few telescopes. Of these the larger are for the most part good. Wray exhibits one with a solid substance, instead of flint glass, which deserves commendation, as a deviation from the beaten path, that may conduct to new and important results. There are few samples in the Exhibition of optical glass; but all are good, and give great promise of an increase in the use of large telescopes. Simms exhibits several object-glasses made of English glass; and Chance contributes a noble piece of apparently pure flint glass, of no less than 29 inches in diameter. Daguet sends some wonderfully-pure glass, both crown and flint. Of lenses and prisms, there is not one British contributor; France standing alone in the exhibition of some very beautiful work, which reflects high credit upon Bayerle and Bertaud. Of physical optics, there is but one extensive exhibitor, viz., Duboscq-Soleil, France, No. 1197, who has a beautiful collection of most delicately-constructed instruments, adapted for physical investigation. Of microscopes there are a good many exhibited; among which the English microscopes are found to stand preeminent. Of lighthouses there are two, the one being made of glass almost colourless, and the other with that of a greenish colour. The glass of neither is pure, there being many striæ, &c., which must cause much light to be scattered and consequently lost. Of spectacles and cameras we shall speak in the proper place.

Telescopes.

VARLEY and SON (No. 257) exhibit an apparatus to be used in Gregorian telescopes, consisting of three small speculums, grouped together on one stem, and fitted into a telescope, under adjustment from the eye end, by means of which any one of the three may be used at pleasure, so that the power may be changed without losing sight of the object. Within the tube are placed two slides, one near the eye end, adjustable by a screw; the other near the object end, which may be moved to and fro. The latter carries three small speculums, of different foci, mounted on a steel axis, held in a stiff frame. At the bottom of the axis is placed a toothed wheel and rack-work. This rack is kept from moving by a long bar proceeding from the first slide, so that it cannot move with the slide on which it lies; by this arrangement, on moving the slide, the wheel upon it will roll against the rack, and so present the next speculum.

The angle at which the speculums are opposed to each other on the block determines the number of teeth, or portions of the circle required to present each speculum. The diameter of the wheel determines the distance that such portions of the wheel must traverse to put each speculum in true focus. The slide nearest to the eye end is moved by a long bar attached to it by means of a screw, whilst its near end lies on the other slide, and over the loophole. The bar has a screw handle on the outside of the telescope, by which to pull or push the further slide, and also to clamp it fast to the near slide when in the right place. This clamping connects the two slides, and causes both to obey the adjusting screw. In order to determine the exact places at which to clamp, the bar is furnished with three notches, whose distance corresponds with the difference of foci; a tooth snaps into each notch as it arrives; the hand of the observer feels this snap, and the object reappearing at the same instant, the screw is made fast. Having brought each speculum to its right distance, its perfect position is effected without trouble. The speculum wheel has three pins: against one of these a notch in the bar is urged by a spring, which holds its corresponding speculum perfectly in place, and, in addition, moves the wheel and rack a little further than the hand and bar had formerly done. This simple action separates the two hooks, and thereby detaches the apparatus from each speculum whilst it is in use, leaving it at liberty to be governed only by its pin, and the notch in the bar already mentioned: the speculum by these means is held perfectly in its place. A cylindrical cap, as a protection from the weather, is made to slide over the speculums, and affords a dark margin round the pencils of light. This contrivance has been applied to telescopes of eight inches focal length, and six inches aperture.* The Gregorian form of telescope is the shortest, and consequently best supported on the stand, and possesses many advantages, as compared with others of equal power; from its large proportionate aperture, it gives a smaller disc to the stars, and does not require a deep eye-piece; but it is desirable to obtain power by deeper and smaller speculums.

Varley and Son also exhibit a portable Gregorian telescope, of two inches aperture, and six inches focus. It is mounted on a brass stand, and admits of being readily packed away in a small box. When held against a post or tree, the foot and telescope form a firm triangular bearing.

As in ordinary Gregorians, the length of telescope increases the power of the small metal reflector, so that a small portion only of an object can be seen at one time through the central aperture: it follows that, with a sufficient field of view, we cannot have as low a power as would be desirable, without increasing the central aperture and the small reflector so much as to injure the telescope for the reception of high astronomical powers. To obviate this, if possible, Varley and Son have, in the first instance, made the great speculum of the shortest eligible focus, by which means the power of the small speculum is lessened and brought nearer, the angle of view being increased in the same degree. The small speculums are mounted in tubes of any length less than double their focus. This arrangement gives a more effective dark margin around the pencils of light, and such as would require a larger disc if *placed behind the speculum. Small speculums* of longer focus may thus be used with no greater obstruction of light, and an equally good field retained with a lower power. The mounting the small speculums in tubes effectually secures them from injury whilst in place, and,

* This contrivance received last year (1850) the large Silver Medal from the Society of Arts.

when removed, a small cap completely excludes them from the air. The arm which supports them remains in the tube, it having a concentric ring, into which the small tubes are screwed for use, and from which they are more easily detached than when affixed to separate slides in the common way.

ROSS (No. 254) exhibits a telescope of 3 feet focal length and 2½ inches aperture, of English flint glass, which, examined on test objects at 150 yards (consisting of two black marble balls, highly polished, placed in full sunshine—a watch-dial, and small balls of white ivory on a black ground), was found to perform well, giving well-concentrated images of the artificial stars so produced on the marble balls, with but a small trace of uncorrected colour.

A Council Medal was awarded to Mr. Ross for this telescope in connexion with microscopes.

CALLAGHAN (No. 268) exhibits a telescope intended for use in deer-stalking.

SALMON (No. 266) exhibits several day and night telescopes, intended for ships' use, which are good for their price.

RICHARDSON (No. 264) exhibits a small reflecting telescope, of 3 feet 8 inches in length. The large reflector, made of one piece of solid crown glass, was either painted, or had paper pasted against its back, thereby giving it that tendency to change figure by heat, against which Sir John Herschel has so strongly cautioned all constructors of glass mirrors.

BOYLE (No. 392) exhibits a reflecting telescope, intended for use without a tube.

WRAY (No. 309) exhibits a seven-foot refracting telescope, 4½ inches aperture. The peculiarity of this telescope is the substitution of a solid substance instead of flint glass. (See Illustrated Catalogue.)

On trial it was found to be badly achromatised. The colour above the image did not seem to be that usually called the secondary spectrum, but a remain of colour not fully compensated. The glass was neither fully corrected for sphericity nor for colour. It was observed that the object lens had rather a strong yellow tint, and was somewhat blotchy, as if the material used was not quite uniform in colour; all interior reflections were destroyed, so that it could not be suspected to be other than a single glass. As a telescope it is not very good; but, though an imperfect trial, is yet a fair attempt to move out of the beaten track, and, as a step towards the possible revival of fluid or semifluid object-glasses, deserves commendation.

WATKINS and HILL (No. 659) exhibit a telescope 3½ feet focal length, and diameter of object-glass 2¾ inches, furnished with a finder, vertical and horizontal rack-work motion, and eye-pieces with powers to 220.

MARRATT (No. 409) sends an achromatic telescope of 5 feet focal length; it is furnished with powers of 65, 85, 120, 200, and 280. On trial it was found to be good, and to deserve Honourable Mention.

HARRIS and SON (No. 149) have a micrometrical and double-image telescope and "coming-up glass," for measuring distances either on land or sea.

This instrument is designed for the purpose of ascertaining the distance and dimensions of any inaccessible object by means of simple calculation; also to determine, without calculation, the distance of any known object, by means of a set of tables adapted to the scale. It is intended to act as a micrometer for the purposes of astronomy, and as a "coming-up glass," to ascertain whether a ship be approaching to the observer or receding from him, and withal to combine simplicity of construction.

BURON (France, No. 443) exhibits a telescope, the object-glass of which is of rock crystal, 4 feet 2 inches in diameter, and 6 feet 3 inches focal length. Attached to the telescope is a finder, which embraces a field of view from 5 to 6 , and has cross wires, which, owing to the great illumination of the field, may be seen during the darkest night, and consequently the star brought into the centre of the field. On examining this instrument it was found to be good in every respect. It is fixed upon a very steady cast-iron stand, furnished with three small castors, brought into operation by means of rack-work, when necessary to remove the instrument.

The object-glass of this telescope is of rock crystal, which requires great care in its preparation on account of its property of double refraction. In its working, the following particulars are necessary to be attended to :—

1. The crystal must be cut perpendicular to its axis.

2. In working the axis, the spherical surface must always coincide with the axis of crystallization.

3. The curvature of their surfaces must not be made too large in the angles, as double refraction would then be visible to the eye.

M. Biot has shown that an angle of 5″ must always exist, but that this is not visible to the eye.*

The formula of Huygens has been used in working the rock-crystal object glass; it is as follows :—Supposing that the refractions, both ordinary and extra ordinary, take place in the plane of the principal section,

$$m' = \sqrt{\frac{m^2 \cdot m''^2 (1 + a^2)}{m^2 \cdot a^2 + m''^2}},$$

in which m' = The index of refraction.
m = The ordinary index, or minimum.
m'' = The extraordinary index, or maximum.
a = The tangent of the angle of ordination of the luminous rays with the axis of the lens.

Thus m' is always an index of refraction, intermediate to m and m''.

M. Buron has also exhibited another telescope of about the same dimensions, which was found to be good. It is supported upon a stand, invented by the late M. Cauchois, the appearance of which is elegant; but as it compels the observer to stand during the time of observation, and as it is necessary to be moved entirely when large azimuthal angles have to be passed over, it is less convenient than the cast-iron stand before described. It is made of wood, which, though rendering it liable to be affected by variations of moisture, gives it the advantage of being lighter than one constructed of iron.

M. Buron has also exhibited telescopes of various sizes, provided with terrestrial and celestial eye-pieces, and mounted upon brass stands; also nautical and pocket

* See Biot, Traité d'Astronomie Physique, vol. ii., 1844, and vol. iii., published in 1846; also Mémoires sur les Oculaires Multipliées et Achromatiques, présentés à l'Académie des Sciences, 1843.

telescopes. In the construction of his eye-pieces, M. Buron pays strict attention to the rules of M. Biot.

Many of the portable telescopes were tried, and their performance was found to be very good; they are remarkably cheap.

A Council Medal was awarded to M. Buron.

LEBRUN (France, No. 298) exhibits several achromatic telescopes of a very good kind, and which are remarkably cheap.

KINZELBACH (Wurtemburg, No. 26) has exhibited an achromatic telescope of about 2½ inches aperture, and 23½ inches focus, constructed on the dialytic principle, in which the correction of the dispersion of the crown lens is performed by a flint lens of only half the aperture, placed midway between the crown lens and the joint focus; a principle of compensation originating theoretically, we believe, with the late Mr. Rogers, of Leith, and carried into practice with much success by Plössl. This instrument was found to give very perfect images, with no uncorrected colour: this, together with its being the only telescope of the kind exhibited, and the construction deserving of encouragement, has induced the Jury to consider it worthy of a Prize Medal. It is mounted on a stand, which, though defective in solidity, may be used as an equatorial mounting in any latitude.

BUSCH (Prussia, No. 89) exhibits an achromatic telescope of 5 feet focal length and 48 lines aperture. On examination this telescope was found to be pretty good. The same exhibitor has fourteen other telescopes of a small size. Honourable Mention is awarded to Mr. Busch.

Microscopes.

The Exhibition is rich in its collection of microscopes of all kinds, comprising instruments varying from the simplest forms to the most elaborate. Many of the latter have never been surpassed for power, goodness of object-glass, definition, large angular aperture, beauty of workmanship, great convenience of the subsidiary parts, combined with great permanence of adjustment.

The microscope has been rendered second in importance only to the telescope by its application to physical researches. To the science of geology, it has been made to display its great powers in the discovery of many strata of considerable thickness, almost entirely composed of infusorial remains, too small for the naked eye to distinguish or appreciate their exquisite beauty of form and structure. To members of the medical profession its services are indispensable; and in various ways it may become of essential use to every class of society. By knowing the microscopic appearance of different articles, a microscopist may, with ease, detect adulteration in any form—as in adulterated bread or flour for instance, the presence of any grain other than that of wheat will be readily discovered, the starch in each variety of grain being possessed of a distinctive character; and in textile fabrics the intermixture of cotton with linen can be immediately detected. But these are two isolated illustrations out of many far too numerous to be mentioned.

When Tulley constructed the first achromatic object-glass in this country, in the year 1824, Dr. Goring said, "that microscopes were now placed on a level with telescopes, and, like them, must remain stationary in their construction."*

* Exordium to Microscopic Illustration, 1829.

This prediction fortunately has not been verified, as the most careful examination of the instruments in the Exhibition has fully exemplified. To trace the causes of the steady and progressive improvements which have resulted in the production of microscopes of such perfection as those exhibited is most desirable. Mr. Bowerbank, who has always taken an active part in these improvements, has kindly furnished the necessary information.

About the year 1824, the first effective movement was made towards applying achromatic object-glasses to the compound microscope. In the same year the report of Selligue's microscopes was made to the Royal Academy of Science; and Amici resumed the subject after an interval of nine years. The late Mr. William Tulley produced, on March 1st, 1824, at the instigation of the late Dr. Goring, his triple glass, $\frac{1}{8}$-inch focal length, it being the first achromatic combination for the microscope made in this country. But in the following year, on Mr. Lister showing him the disadvantageous figure of this construction, he altered it to his well-known nine-tenths. This glass had an aperture of 18 degrees, and worked well with eye-pieces to about 120 linear. Subsequently a second smaller triplet was placed before the nine-tenths glass, and a power was obtained, with beautiful definition, of 300 linear, with a pencil of light of 38 degrees. The glasses thus combined were about equal to a lens of three-eighths of an inch focus.*

With a happy combination of mathematical knowledge and practical experience, Mr. Lister continued to pursue the subject, and in the year 1830 he published in the "Philosophical Transactions" his paper on aplanatic foci of the double achromatic object-glass, with other properties belonging to it, and a means derived from them of correcting by combination both spherical and chromatic aberration and coma. Upon this communication has been based the whole of the progressive improvements to their present state of perfection. Although the author of this paper has not since published the further fruits of his labours, he has continued his exertions, and the results have been freely communicated to those celebrated makers among our own countrymen, who have aided and assisted him by their abilities in obtaining the beautiful achromatic combinations, which are now so abundant among our ablest anatomists and naturalists.

Mr. William Tulley, who led the way in the manufacture of achromatic combinations, died about the close of the year 1835. At this time Messrs. Ross and Powell had taken up the manufacture, but without much advance on the first simple application of the principle until the beginning of 1837, when, at the suggestion of Mr. Lister, Mr. Ross constructed a differently-arranged combination, but on the same basis. It consisted of two double and one triple compound lens. This combination was successfully worked out, and was designed to produce a great increase of defining power; and it was at this time that the thought occurred to Mr. Ross to leave the front lens moveable, so that by varying its distance from the others, the glass might be adjusted either for covered or uncovered objects.

In the summer of the same year a new construction, composed of two achromatic lenses for a lower power, was suggested by Mr. Lister, and executed by

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* See "Quarterly Journal of Sciences" for 1825, No. 37, p. 132; also for 1827, No. 44, p. 265. Specimens of these combinations are still in the possession of Messrs. Lister, Bowerbank, and Loddiges.

Mr. Ross. In 1843, Mr. Ross constructed a combination of two triplets and one doublet, by means of which an increased angle of aperture and improved definition were obtained. One or the other of the above combinations are now employed by our three chief makers,—Messrs. Powell and Lealand, Ross, and Messrs. Smith and Beck, to whom Mr. Lister also communicated the results of his experience in the construction of achromatic combination, each occasionally surpassing the others in the quality of the glasses; and their successive exertions have resulted in that superiority of the numerous and beautiful combinations which they have produced over all others in the Exhibition.

To Sir David Brewster we are indebted for many valuable suggestions for the improvement of the instrument, especially for the best method of illuminating by transmitted light, by the application beneath the stage of achromatic combinations, in place either of simple reflection of light from plane or concave mirrors, or of its concentration by means of the Wollaston condenser. By this method of illumination, minute and delicate objects during examination are presented to the eye under the most favourable circumstances, and a beauty and correctness of definition obtained which no other mode of illumination is capable of producing.

To the same source we are likewise indebted for the valuable application to the microscope of the apparatus for the polarization of light, which has so powerfully assisted us in the investigation of delicate and transparent animal and vegetable tissues.

In conclusion, it may be observed that the low-priced instruments exhibited by Messrs. Ross, and Smith and Beck, are deserving of high commendation. The brass-work is good in principle, steady and free from tremor in operation; and the powers varying from 1-inch to a quarter-inch focus, inclusive, are by far the most generally useful in the whole range of microscopic combinations, especially for educational purposes.

It must be remarked that it is advisable that the angle of aperture of the combinations should not be extended to its utmost possible limit, when destined for the general purposes of natural history or anatomical investigation.

Combinations of high power, and extremely-extended angles of aperture, are excellent in developing one class of test objects, viz., minute lines or dots on plane surfaces, and admirably demonstrate the high perfection to which such glasses are capable of being carried by scientific opticians; but such combinations, with a less angle of aperture and more penetrating power, are far more generally useful and valuable to the minute anatomist and the naturalist.

In regard to the brass-work, we may observe that the qualities especially requisite in the stand of a microscope are simplicity of construction, portability, combined with sufficient weight to insure safety and steadiness, with smoothness and accuracy of action in all the working parts, and such a construction as to distribute any tremor that may be communicated to the instrument equally over its body, stage, and other working parts. These desirable points are admirably attained in the form suggested by Mr. George Jackson, and adopted by Messrs. Smith and Beck, Ross, and other makers. For purposes of delineation, Nachet's (France, No. 1370) form of prism is more advisable than that of Wollaston's, as the former, having one reflection less than the latter, presents the image to the eye in an erect instead of in an inverted position.

We now proceed to discuss the particulars of each instrument.

Ross (No. 254) exhibits a microscope, the mechanical parts of which are exceedingly good: the movements are very smooth and true; the stand is on a plan which is solid and steady, and at the same time not cumbrous. The object-glasses are constructed with different kinds of glass in the different compound lenses, forming a combination so as to double up the secondary spectrum, and this is done so well that scarcely any separation of colours can be detected. The angular apertures of the object-glasses examined are as follows:—

1-inch	focal length,	27°	aperture.
$\frac{1}{2}$-inch	,,	60°	,,
$\frac{1}{4}$-inch	,,	113°	,,
$\frac{1}{8}$-inch	,,	107°	,,
$\frac{1}{12}$-inch	,,	135°	,,

Both the half-inch and the one-eighth of an inch foci are purposely made of smaller proportionate aperture than the quarter-inch or the one-twelfth of an inch, as in all lenses of large aperture the image becomes indistinct from the slightest change of focus, and so unless an object be an absolute plane, it is impossible to see the whole field tolerably distinct at once with an object-glass of large aperture. In the set examined, the inch, the half-inch, and the one-eighth of an inch, are intended for the general examination of objects; and the one-fourth and one-twelfth of an inch for the examination of minute structures. The object-glasses are first rate. A Council Medal was awarded to Mr. Ross.

Smith and Beck (No. 253) exhibit a microscope, the stand of which in appearance is not highly finished; but their forbearance to expend time and money on elaborately finishing the non-working part has been adopted on the strong recommendation of some of the oldest naturalists in London, in order that students may acquire instruments with first-rate glasses at the least possible expense, and that such instruments may be brought within the compass of those whose means are limited. The stand is excellent in principle: the body, stage, and appliances beneath are all carried on one stout cast bar, on the recommendation of Mr. E. Jackson, by means of which the centering of the achromatic illumination is rendered easy and certain, and on any tremor being communicated to the instrument, it is equally distributed over the whole of the working parts.

The lever motion to the stage of this instrument is the most easy and generally useful that has yet been applied. If used with the right hand, while the quick and slow adjustments to the focus are worked with the left, there is no animalcule that cannot be readily followed, however fitful and rapid its movements; and any globule of blood pursuing its course through the most tortuous of the capillaries, can be steadily and easily traced, and every alteration of its form observed during its passage through these minute vessels. The field of view may also be swept horizontally or perpendicularly, and the most delicate micrometrical measurements made with great ease and precision. This stage is the invention of Mr. Alfred White; the rabbited groove on which the body moves was suggested by Mr. George Jackson, at whose recommendation the fulcrum of the stage movement was fixed to a spring, instead of to a rigid bar. The simplicity and efficiency of the whole of this stand is highly commendable.

The object-glasses examined were of first-rate quality, and were as follows:—

$\frac{2}{3}$-inch	focus of	45° aperture.
$\frac{1}{2}$-inch	„	70° to 75° aperture.
$\frac{1}{16}$ inch	„	60° aperture.
$\frac{1}{8}$-inch	„	100° to 105° aperture.

They are beautifully corrected for spherical aberration, but the secondary speculum has not been much diminished. The half-inch focus of 70° aperture is a wonderfully-fine combination, easily showing objects, considered difficult for a one-eighth inch focal length a little more than a year since, and bearing the application of the higher eye-pieces in an unprecedented manner.

Smith and Beck also exhibit all that is necessary for the mounting of microscopic objects, as cells, slips, thin glass, fluids, covers, &c., and a few preparations as specimens. There is, also, a new form of cabinet, for the reception of objects, the names of which may be exposed, by means of porcelain labels with which they are furnished, and from which the pencil-writing can be easily effaced.

There are two tables with revolving tops, by which the microscope can be turned readily round for the convenience of examination by different observers, and thus rendered a social instrument. The microscopes are furnished with portable silver reflector and annular condenser, which exhibit transparent objects upon a dark ground. (This invention was made by Mr. Wenham, and Smith and Beck claim its first execution.) A Council Medal was awarded to Messrs. Smith and Beck.

VARLEY and SON (No. 257) exhibit a microscope, the stage of which is moved by parallel rods, with ball-and-socket joints, which gives an equable motion in all directions, and is specially adapted for the examination of living objects. A second microscope is exhibited, adapted for receiving vials in which aquatic plants or animalculæ may be kept in a living state for any length of time. The plant is secured to one side of the vial by a piece of cork, and thus is within the reach of the microscope. The vial is kept full of water, and is only corked when used, at which time it is held in a jacket to cut off all extraneous light; a dark chamber projects from it, opposite to the magnifier, so that a single beam of light may be made to fall upon the part under examination.* A third microscope, of a simple construction, is also exhibited, chiefly intended for beginners.

Varley's lever stage is very much more complex than White's; and as the lever is placed behind the stage it is less convenient to use.

KING (No. 287) exhibits a microscope stand, with micrometers and goniometers. It has a pyramidal tripod, with stage traversed in rectangular planes by micrometer screws. The parts of this instrument are so arranged that its weight is equally distributed over the base, and when inclined at its working angle, the principal weight is below the point of suspension, and the stand is steady and good. The traversing-stage is furnished with divided scales and verniers. The workmanship throughout this instrument is of the first order. It is furnished with many ingenious applications of subsidiary instruments, and of apparatus specially adapted to the examination of objects by polarized light, and goniometric apparatus for

* This instrument is fully described in the "Transactions of the Society of Arts."

measuring the angles of microscopic crystals. The mode of illumination, by a prism worked into convex spherical surfaces, is also worthy of notice. The Jury considered Mr. King as well deserving Honourable Mention.

PRITCHARD (No. 248) exhibits an old-fashioned achromatic microscope, with indifferent object-glasses. The working of the mechanical parts is very good. This form of instrument is that which led the way in the great advance that has been made in the microscope by the introduction of achromatic object-glasses. The Jury voted Honourable Mention to Mr. Pritchard.

LADD (No. 291A) exhibits a microscope furnished with chain-and-spindle movements, in place of rack and pinion. This movement has been applied to the microscope many years since, by Mr. Julius Page. The motion is smooth, and totally free from loss of time, and is likely to stand well the effects of constant use. The Jury award Honourable Mention to Mr. Ladd.

PILLISCHER (No. 269) exhibits a large microscope stand, which is good for its price, but unnecessarily large and inconvenient for use. He also exhibits two small microscopes.

JACKSON, E. and W. (No. 315), exhibit plain and excavated slips of glass, sections of tubes of various forms, for the construction of cells for mounting wet preparations, and thin glass for covering them, of various thicknesses. These materials are exceedingly useful for scientific microscopists.

HUDSON (No. 256) exhibits microscopic objects intended for the use of the medical student, physiologist, and naturalist.

HETT (No. 249) exhibits a variety of admirably-injected microscopic objects, illustrating the utility of the microscope to the physiologist. A Prize Medal was awarded to Mr. Hett.

POULTON (No. 252) exhibits some well-executed microscopic objects, with drawings to illustrate their structure.

STARK (No. 284) exhibits microscopic objects, mounted in *gutta percha* cells, instead of *glass;* and also slides for exhibiting opaque objects.

SHARP (No. 308) exhibits a set of high-power lenses, ten in number, for a microscope from one-tenth to one-hundredth of an inch focal length.

SHADBOLT (No. 677A) exhibits a sphero-annular condenser, for concentrating light on transparent objects while under microscopic examination, the object alone being illuminated whilst the field of view is dark. A Prize Medal was awarded to Mr. Shadbolt.

The principle of this condenser was suggested by Mr. J. F. Wenham, of Brixton, in his parabolic condenser. Mr. Shadbolt's condenser carries out Mr. Wenham's principle, with the advantage of superior reflecting arrangements, greater facilities of construction, and less liability of derangement.

Other microscopes are exhibited by FIELD and SON (No. 250), ELLIOTT and SONS (No. 320), WATKINS and HILL (No. 659), ABRAHAM (No. 263), GRIFFIN (No. 457); but they are not such as demand especial notice.

Let us now turn our attention to the microscopes exhibited by France; and first in order is NATCHET (France, No. 1370). The object-glasses, though inferior to both those of Ross, and Smith and Beck, are by far the best of the foreign ones. They vary from a focus of one inch to that of one-eighteenth of an inch. The following were examined; that with—

$\frac{1}{16}$th of an inch focal length, has an aperture of 134°.
$\frac{1}{8}$th " " 108°.
$\frac{1}{5}$th " " 88°.

In all of them the spherical aberration is not corrected; and although the method of adjusting by the separation of the lenses, invented by Ross, is adopted, yet the system is such that they are not correct at any distance. The workmanship of the stand is very good; and there are two ingenious forms of microscopes exhibited. One has the object-glass below the stage, with the tube inclined at a convenient angle, and a reflecting prism for the examination of chemicals, or for dissecting transparent objects under fluids. The other is a dissecting microscope, with the body inclined in a convenient direction, and the image erected by reflecting prisms, so as to enable an observer to look in a convenient position whilst dissecting an object in fluid, which must be kept horizontal. A Prize Medal was awarded to M. Natchet.

Some microscopes excellent for their price are exhibited by BERNARD (France, No. 762). These instruments are the cheapest in the Exhibition, though none are of the first order. Honourable Mention is awarded to Mr. Bernard.

CHEVALIER (France, No. 1729) exhibits a microscope, with indifferent object-glasses. The workmanship of the mechanical part however is very good, the mode of mounting is excellent, and the instrument is convenient for all kinds of microscopic observations. The Jury voted Honourable Mention to M. Chevalier.

Some excellent microscopes, for their price, were also exhibited by BURON (France, No. 443).

MERZ (Bavaria, No. 30) exhibits a microscope, the mechanical parts of which are beautifully executed. The object-glasses are of small aperture, and the spherical aberration is not corrected. The one-twelfth of an inch focus has an aperture of only 65°, and the one-eigthth of an inch that of 55° only.

HAZART (America, No. 16), a large instrument, furnished with very deep Huygenian eye-pieces, giving the usual extensive field obtained by such; it has, besides, two convex lenses in the body for enlarging the field of view. Neither chromatic nor spherical aberration is properly corrected, and the workmanship is not good.

PICK (Russia, No. 170) also exhibits a microscope, but it is an indifferent instrument.

We will now speak of some of the uses of the beautiful instruments we have just described; the most important illustration of their utility in the Exhibition is shown by LEONARD (No. 306) in his correct representation of many different substances, &c., when highly magnified. He has selected several articles of food in daily use, also the substances with which they are sometimes adulterated, &c., as in the subjoined list.

Frame 1.

1. Transverse section of raw coffee berry, magnified 16 diameters.
2. Thin section of raw coffee berry, showing globules of essential oil, magnified 250 diameters.
3. Investing membrane, magnified 250 diameters.
4. Transverse section of chicory root, magnified 250 diameters.
5. Longitudinal section of chicory root, central fibres, magnified 250 diameters.

6. Longitudinal section of wheat-grain, showing the embryo.
7. Wheat-starch, magnified 250 diameters.
8. Investing membrane, 250 diameters.
9. Maize, longitudinal section, showing the embryo, magnified 12 diameters.
10. Maize starch, magnified 250 diameters.
11. Investing membrane, magnified 250 diameters.

Frame 2.

1. Horse-bean, transverse section, magnified 25 diameters.
2. Horse-bean, starch globules, magnified 500 diameters.
3. Horse-bean, investing membrane, magnified 500 diameters.
4. Potato starch, magnified 500 diameters.
5. West India arrow-root, magnified 500 diameters.
6. Sago meal, magnified 500 diameters.
7. Rice (raw), magnified 500 diameters.
8. Rice (boiled), magnified 500 diameters.

Frame 3.

1. Healthy nurse's milk, magnified 1200 diameters.
2. Pure cow's milk, magnified 1200 diameters.
3. Cream of cow's milk, magnified 1200 diameters.
4. Curd of cow's milk, magnified 1200 diameters.

Frame 4.

1. Adulterated milk, magnified 1200 diameters.
2. Calves' brains, magnified 1200 diameters.
3. Milk, with linseed tea, magnified 1200 diameters

Frame 5.

1. Human bone, a thin transverse section of the clavicle, magnified 95 diameters.
   Small portion of ditto, magnified 440 diameters.
2. Ostrich bone, transverse section, magnified 95 diameters.
   Small portion, magnified 440 diameters.
3. Turtle bone, transverse section, magnified 95 diameters.
   Small portion, magnified 440 diameters.
4. Hoof of horse, transverse section, magnified 95 diameters.
   Small portion, magnified 440 diameters.

Frame 6.

1. Lepidosteus scale, transverse section, magnified 95 diameters.
   Small portion ditto, magnified 440 diameters.
2. Sword-fish, transverse section of the sword, magnified 95 diameters.
   Small portion ditto, magnified 440 diameters.
3. Spine of ray, from which shagreen is made, magnified 95 diameters.
   Small portion, magnified 440 diameters.
4. Human lung (healthy) injected, magnified 150 diameters.
5. Human lung (with tubercles) injected, magnified 150 diameters.

These anatomical and microscopical drawings deserve very Honourable Mention: the whole of their outlines and proportions have been executed by means of the camera lucida, so that they represent truly what the eye actually sees, and the details are finished with scrupulous accuracy; they are, therefore, among the most trustworthy representations of minute and elaborate tissues that perhaps have ever been executed.

TOPPING (No. 667) exhibits five cases of microscopic objects. The contents of the first case are,—test objects adapted to the present state of microscopic science, ranging from a two-inches power up to one-twelfth of an inch of large aperture; also some of the most beautiful of the fossil infusoria.

Case 2—contains fossil and recent vegetable structures.

Case 3—dissections of insects. In this case are large dissections of the respiratory systems of the silkworm, caterpillar, and larvæ of beetles: all these are mounted in Canadian balsam.

Case 4—sections of fossil teeth, bones and shells, &c. In this case there is a diamond showing woody structure, and sections of oriental and Scotch pearls.

Case 5—contains injected animal tissues.

Mr. Topping has mounted the greater part of these objects in Canada balsam: he remarks that this is the only medium which will permanently preserve specimens of natural history as objects for the microscope, and that he uses chrome yellow, instead of vermilion, for injections, with which material he can inject the minutest capillaries.

Mr. Topping's methods of mounting and preserving objects are many of them of his own invention. He deserves to be distinguished above other exhibitors, as he was one of the first in the field, and perseveringly overcame many difficulties which others following after had not to encounter. His anatomical injections are admirable, as are also those of Hett (No. 249); but in this branch neither of them are original inventors, but followers of John Quekett, Esq., of the Royal College of Surgeons. A Prize Medal was awarded to Mr. Topping.

BOURGOGNE (France, No. 434) has exhibited a case of microscopic objects prepared in the usual manner. They are mounted in Canada balsam, and consist of sections of wood, and entomological and other preparations, with a selection of salts to illustrate the polarization of light. The objects are well displayed and carefully mounted. A Prize Medal was voted to M. Bourgogne.

NOBERT (Prussia, No. 77) of Barth, has exhibited his wonderful tracings on glass. The plan adopted by him is to trace on glass ten separate bands at equal distance from each other, each band being composed of parallel lines of some fraction of a Prussian inch apart, in some they are $\frac{1}{1000}$th, and in others only $\frac{1}{4000}$th of a Prussian inch separated.

The distance of these parallel lines form parts of a geometric series; thus—

0·001000 line.
0·000857 „
0·000735 „
0·000630 „
0·000540 „
0·000463 „
0·000397 „
0·000340 „
0·000292 „
0·000225 „

To see these lines at all it is necessary to use a microscope with a magnifying power of 100 diameters; the bands containing the fewest number of lines will then be visible. To distinguish the finer lines it will be necessary to use magnifying power of 2000, and then the lines which are only $\frac{1}{47000}$th of an inch apart will be seen as perfectly traced as the coarser lines. Of all the tests yet found for object-glasses of high power these would seem to be the most valuable. These tracings have tended to confirm the undulating theory of light, the different colours of the spectrum being exhibited in the ruled spaces according to the separation of the lines; and in those cases where the distances between the lines are smaller than the lengths of the violet light waves, no colour is perceived; and it is stated that if inequalities amounting to ·000002 line occur in some of the systems, stripes of another colour would appear in them.* A Prize Medal was awarded to Mr. Nobert.

LENDY (Sardinia, 60) has exhibited several dies or minute copies on silver and steel, of various devices. These specimens of minute and excellent workmanship are produced by a machine invented, but not exhibited, by Mr. Lendy. By its means, any model, however elaborate, varying in size from 7·87 in. to 0·039 in. in diameter, may be reduced to one-fifteenth of its original size, a degree of minuteness which renders the copies so reduced almost imperceptible to the naked eye. On subjecting them, however, to examination by the microscope, they are found to be composed of lines of all but unparalleled delicacy and distinctness.

Mr. Lendy, who has been for many years engraver to the Royal Mint at Turin, has originated this ingenious invention, for the use of banks, mints, goldsmith's companies, &c., with a view to the avoidance of counterfeits. We may particularize the following dies or puncheons which are exhibited:—

A royal crown engraved on silver, and very elaborate, the lines within side being so fine, that a common hair covered five of them. The same design in relievo is also exhibited.

A ducal crown engraved on silver, and surrounded by a gothic frieze, executed with sharpness and precision never before equalled in so minute an object. The same design in relievo is also exhibited.

A coat of arms containing a Gothic "R," surrounded by a Gothic frieze, and engraved on steel, 0·013 in. in diameter; in its execution it is as graceful as distinct. A similar design in relievo is also exhibited.

Another ducal crown on steel, equally good with the preceding, is exhibited, as also one in relievo.

Upon steel a copy of Mr. W. Wyon's medal (the design of which is a portrait of Her Majesty, surrounded with the words Victoria, D. G. Britanniarum Regina, F.D.), it is 0·06 in. in diameter, the original being 1·8 in. in diameter. This is a most elaborate work, and bears examination well by high powers.

This invention, apart from its great ingenuity and the perseverance by which it has been originated, promises to be of great utility in reducing standard works with accuracy only exceeded by a degree of minuteness calculated to render any attempt at counterfeit next to impossible.

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* See Poggendorff's "Annalen" for 1846, and "Proceedings of the Royal Society," April 10, 1851.

Object-glasses for Telescopes.

Simms (No. 741) exhibits several achromatic object-glasses; viz., one of 9 inches aperture, two of 8 inches aperture, one of 6·9 inches aperture, and one of 4 inches aperture. The largest which is exhibited is entirely of English manufacture, and the discs, both of flint and crown, were made by Messrs. Chance, of Birmingham. In all the remaining glasses the crown is of English and the flint of foreign manufacture. The object-glasses are altogether the work of the exhibitor, and on their examination were found to be good.

It is observable that the crown glass in all these specimens has a greenish hue; and Mr. Simms states, with reference to this particular, that he has found from experience (as might be expected from the extinction of one extreme, and consequent shortening of the total spectrum) that there is less irrationality between this kind of crown glass and the denser kind of flint, than between the same specimens of flint and any other crown or plate glass that he has been able to procure. We understand Mr. Simms' practice in determining the corrections required for achromatism consists in using that part of the spectrum which is included between the lines B and G; he finds, however, differences of small amount, sufficient to produce a sensible effect upon the results, between discs of glass sent to him at the same time, and which he supposes are prepared, if not at the same time, at least of the same materials.

The following are the specific gravities, &c., of specimens of flint and crown glass manufactured by Messrs. Chance and Co., of Birmingham:—

Kind of Glass.	Specific Gravity.	Index of Refraction B.	Index of Refraction G.	Dispersive Power B. to G.
Flint . . .	3·583	1·6109	1·6336	0 036
Crown . .	2·539	1·5128	1·5274	0·028

To Mr. Simms the Jury consider very great merit is due, not only for the exquisite workmanship displayed in every instrument exhibited by him, but also for the *several new inventions and arrangements* which, by the greater facility they afford to observation, cannot fail in the advancement of astronomy. The Jury unanimously voted a Council Medal to Mr. Simms, which award was passed unanimously by the Group, but unfortunately was not confirmed by the Council of Chairmen; consequently the Medal which Mr. Simms will receive is not that which, in the opinion of the Jury, is due to him.

Goddard (No. 274) exhibits an object-glass.

Buron (France, No. 443) has exhibited an achromatic glass 7·5 inches diameter and 10·8 feet focal length; the crown and flint glass for which were made by the late M. Guinard, of Paris, and the curves according to the theory of Sir John Herschel, and is designed to show stars of the eleventh magnitude. It was not tried by the Jury, on account of its tube being delayed at the Custom-house under a very heavy charge.

Solid Eye-pieces.

READE (No. 254A) exhibits two solid eye-pieces. They consist of three lenses, the anterior and posterior being double convex of crown glass, and the intermediate one double concave of flint. The contact surfaces are cemented together, and consequently the action upon the rays of light is similar to that of a single lens. They are applicable to all astronomical instruments, micrometers, and microscopes, and also as a general magnifying power. The novelty of the solid eye-piece consists in its construction, by which a large and flat field of view is obtained, together with the removal of spherical and chromatic aberration. These advantages are obtained by means of the great thickness of the flint lens, which is a perfectly new feature in the construction of eye-pieces.

Sir David Brewster's achromatic sphere, which he proposes to use as an object-glass for the microscope, approximates to this form, but the field is not flat. The general mathematical expressions for the curves of the solid eye-piece have not as yet been fully worked out; but it may be stated as a rule for the practical optician, that the radii of the outer curves of the two convex lenses, must be in the proportion of the dispersive ratio of the crown and flint glass employed on each eye-piece, and the inner contact surface must be such as by experiment will perfect the achromatism. The solid eye-pieces exhibited have focal lengths of 0·5 inches and 0·75 inches, and it happens that while the eye-piece of shorter focal length is barely brought up to a flat field of view, the one of longer focal length is carried rather beyond, and is therefore slightly over-corrected. These small errors are upon the whole satisfactory, inasmuch as they show that a truly flat field is attainable.

Sir David Brewster observes in his Treatise on Optics, that "achromatic eye-pieces, where one lens only is wanted, may be composed of two or three lenses, exactly on the same principle as object-glasses; such, indeed, as the cemented triple object-glass made for the microscope, which was described by the Rev. J. B. Reade some years ago, in a paper read before the Royal Society, as being an efficient eye-piece for telescopes—in fact, the then best-known form of a vertical single lens; but the smallness of the field is an insuperable objection to its use with a micrometer. The larger field of view now obtained in the solid eye-piece is solely due to the thickness of the flint, which causes the image of the object-glass, where the eye is placed, to be formed so near the eye-piece that its diameter is seen under a considerable angle; and it is found that in the lower powers the diameter of the field of view is larger than in the ordinary negative eye-piece.

The positive eye-piece, almost universally used, is known as Ramsden's: the field is flat, which is requisite for a measuring instrument, but it is far from being free from colour.

The Astronomer Royal states* that the positive eye-piece at present used is not achromatic, and cannot be made so; and considerable inconvenience is occasioned by this defect; for when the object is not far from the centre of the field, the chromatic confusion is much greater than that produced by spherical aberration, since it varies as the distance from the centre, and in this confusion there is nothing to point out the centre of the coloured line.

* See Cambridge Philosophical Transactions, vol. iii., p. 56.

The new solid eye-piece is therefore looked upon as an important addition to the working apparatus of an astronomer, inasmuch as the great evil of chromatic confusion, which prevents any accurate measurements at the extremities of the field, does not here exist at all, but the webs of the micrometer, though ever so distant, may be seen as fine black lines. The field of view is also free from illumination by false light; no light is lost as in the usual construction by inner reflection from the surfaces of the lenses, and there is no formation of the false image or ghost of planets, nor of the bright stars which injures the best part of the field.

An examination of this eye-piece, as applied to a telescope, in comparison with the action of the ordinary eye-pieces applied to the same telescope made by Mr. Glaisher, extending over a period of three hours, fully impressed him with its superiority; the field of view was black, and the stars appeared as very bright points. In consequence of the purity of the achromatism it will probably be found that in determining the colours of fixed stars, these eye-pieces may be of essential service. The Jury awarded Mr. Reade the Prize Medal.

Optical Glass.

The disc, of 29 inches in diameter, exhibited by Mr. Chance having undergone a partial examination by the Jury, it was considered that a satisfactory opinion could not be formed of it, owing to the irregularities in its surfaces, until it had undergone the operation of polishing, so as to give it a plane, or nearly plane figure. This operation having been performed by Mr. Ross, and the disc being reported by him fit for further examination, it was agreed to subject it to such on Tuesday, the 9th of September 1851, for which day (it being considered by the Committee desirable to have the attendance of as many of the Jury as could be brought together) a Jury summons was issued, which was responded to by Professors Potter and Colladon, who attended with the Committee, consisting of Sir J. Herschel, Mr. Glaisher, and Professor Miller. Mr. Ross, Mr. Simms, and Mr. Boutems (the latter on the part of Mr. Chance) were also present at the examination.

The dimensions of the disc were as follows:—

Largest diameter	- - - - -	29½ inches.
Shortest ,,	- - - - -	29 ,,
Thickness, from	- - - - -	2·2 to 2·25 inches.

Its weight was stated to be somewhere about 200 lbs. The specific gravity about 3·56 . . . . 3·58. The surfaces were highly polished, and brought to a figure very slightly deviating from true planes, so that no deceptive appearance of striation could possibly arise from irregularities in their surfaces.

The disc was first examined by inspection through faces cut upon its edges. These faces had not been repolished, or brought to a true figure; so that nothing could be gathered from this examination but that no offensive striæ were seen through them.

The state of the disc, as to tension from imperfect annealing, was then tried by passing polarized light through it at right angles and at obliquities, and analyzing the emergent beam by tourmalines and Nicol prisms. It was found to be very remarkably free from indications of tension, only a feeble gleam of whitish light becoming perceptible on some portions of the edges, which might have arisen from the heat of the hands of the persons employed to lift and keep it in position.

It was then placed on edge, and tested by looking very obliquely through it at objects offering broad lights and shadows. During this examination a group of striæ became visible at a spot whose position on the glass was marked, and to which and its near neighbourhood they seemed to be limited.

To trace the limits of this group, and to subject the whole disc to a more rigorous and delicate scrutiny, it was set upright on a table; the room (the Indian tent) darkened, a candle placed 7 or 8 feet behind the disc, and a convex lens of about 5 feet focus and 6 inches diameter, of extremely pure glass, held between the candle and the lens close to the latter. The eye of the observer being placed before the disc in the place of the image of the candle, so as to cover the lens with a glare of light, striæ, it is well known, become distinctly apparent, if existing, in any part of the disc so covered.

Every part of the disc in succession, beginning from the centre, and proceeding outward in radii, was thus carefully examined for striæ. With the exception of a hair or thread, perfectly definite, and of a looped form,  thus, near the centre, and not of the smallest importance in an optical point of view, and a few other trifling threads, originating apparently in minute sand-grains, in various points, and also utterly inoffensive, no appearance of striæ whatever could be discerned over any part of the disc, but at and in the immediate neighbourhood of the place marked.

No *bubbles* of any consequence were noticed in this examination, or on ocular inspection.

Attention being concentrated on the group of striæ thus pointed out, it was found to occupy a space (at its utmost extent) of 6½ inches in length and 2½ inches in breadth, beginning at about 1½ inches from the edge, and having its longer dimension directed towards the centre. The whole of this space was by no means equally affected, and the most objectionable portion was much more limited. This was situated not far from the middle of the space in question; and it was proved decisively that the seat of the worst portion (or nucleus) of the group was almost close to one of the surfaces, by the test of parallax, viz., by placing a mark on the surface *next the eye* on the apparent place of the nucleus, and then tilting the disc right and left. One side (A) being towards the eye, the mark and nucleus remained coincident; and on reversing the disc, and bringing the other side (B) nearest the eye, and making a fresh mark (effacing the former), they coincided only when the visual ray passed perpendicularly through the disc, the nucleus passing parallactically behind the mark, from side to side, on inclining the disc.

As the disc would have to be worked into a concave or convexo-concave lens by which its thickness in the centre would be reduced at least an inch, there is little doubt, therefore, that by acting on that surface near which the nucleus is situated, it, and much of the neighbouring striæ, which are evidently connected with it, would be ground out. Such is the decided opinion of Mr. Ross. In that case, as the whole area occupied by the striated region does not exceed 0·019, or less than one-fiftieth of the total surface of the glass, it might very reasonably be expected that, if worked into an object-glass, the mass of good light would so far overpower the injurious effect of what striæ might remain, as to give a very satisfactory result, and that for many purposes of high astronomy it might prove extremely efficient.

On the other hand, if it should be resolved to sacrifice the defective portion, or so much of it as to leave but a very trifling part of a comparatively inoffensive region still encroaching on the edge (suppose a spot of an inch diameter), it would be practicable to cut out from the whole disc a smaller one of 22 inches ($29 - 1\frac{1}{2} - 5\frac{1}{2}$) diameter, apparently quite perfect in every other part, and of 2·2 inches in thickness. But as this thickness is superfluous, it might be found practicable, by cautiously heating the glass to the softening point, and applying pressure, to extend it in surface whilst reducing its thickness to 22-29ths of its present amount. Supposing this operation successfully performed, and that in the manipulation some portion of the good glass adjacent to the striated part being retained could be pressed inwards, so as to drive out the small striated corner, a disc of 25 inches diameter, of apparently perfect flint glass, would be produced.

The great object glasses of Pulkowa, and of New Cambridge in the United States, do not exceed 16 inches. Compared to this, a 25-inch or even a 22-inch object-glass would be as great a stride in advance, as the Pulkowa lens is beyond the largest achromatics previously constructed.

On these grounds the Committee have had no hesitation in recommending that a Council Medal be given to Messrs. Chance for this disc. They desire it to be clearly understood, however, that no examination to which a disc of glass unworked can be subjected, will afford more than a reasonable probability that a telescope worked from it shall turn out perfect; since, independently of peculiarities in the glass which this kind of examination may fail in detecting (though no better has yet been devised), the perfection of the resulting instrument will still be dependent on that of the crown lens and of the optical workmanship.

MAËS (France, No. 656) has exhibited specimens of a new kind of glass; the basis of which is the oxide of zinc, a certain quantity of borax, a boracic acid being added, to give the glossy character for which the boracic compounds, no less than the silica, are so eminently remarkable, combined with an easier fusibility. As a material in the arts, the Jury have no further concern with this glass, than as regards its probable utility in the construction of telescopes, prisms, and other optical apparatus, for which its extreme limpidity and total freedom from colour, and, so far as appears, from veins and striæ, seem eminently to fit it, and which have induced them to propose its being rewarded with a Medal. The low dispersive power of the zinc compounds, points to its use as replacing the crown glass in achromatic telescopes. Suppose it should be found practicable (and the experiment is recommended to the attention of artists, as one in which, when tried on a very small scale, some success has actually been obtained) to form colourless and uniform glasses in which fluorine enters as a distinguishing ingredient, in combination with silica, alumina, or other materials, the combination of such glass, as a convex lens, with this new material of Mr. Maës, or with ordinary crown glass, as a concave, might be expected to produce achromatic object-glasses of a very perfect description. The coloured dispersion to be removed, being much less than that of crown glass, owing to the peculiarity of the fluoric compounds, which beset the manufacture of flint glass, arising from the intense solvent power of the oxide of lead on the crucibles, and give rise to striæ and veins, would be evaded. Mr. Maës, besides two prisms of his new glass, of the most limpid purity and perfect freedom from veins or striæ, has exhibited two discs of $4\frac{1}{2}$ and 7 inches in diameter, prepared for optical use. In an examination, through faces cut on their edges, no veins or striæ were detected; and, consequently, should there arise no objection to this material, either in point of durability or facility of working, it will probably prove very valuable for the use of the optician. Some small astronomical lenses, in which zinc is substituted for crown, are also shown. Its refractive index is 3·285, and its dispersive ratio, as compared with a flint glass of specific gravity, is as 3·55, to 0·6502.

It has been long a theorem in every treatise on optics, that the achromatic union of the *whole* spectrum cannot be accomplished by any combination of dispersive media, and that two media of different dispersions enable us to unite but two rays precisely, the rest only approximating, leaving two masses of ~~uncemented~~ uncorrected colour, the one converging to a longer, the other to a shorter, focus than that of the united rays. A fitting combination of three mediæ, admits of the exact union of three rays at different points of the spectrum, and a very much greater approximation to union among all the rest, provided their *scales* of action on the different rays of the spectrum differ sufficiently. In this point of view, the new glass, whose dispersive action on the spectrum, from the introduction of a new metallic oxide, may very reasonably be expected to differ from those of the crown and flint glass, will, perhaps, become available on this third medium, so long a desideratum in optics; and its use may open a new field in the theory of the construction of telescopes. Should it prove (owing to the boracic acid it contains) less durable, or more open to atmospheric corrosion, than the other media, its place in a compound lens will be intermediate, as a defence from air or moisture, and one of the conditions of the structure may be that of a perfect coincidence of one or of both its surfaces, with those of the adjacent lenses, to allow of cementing them. A Prize Medal was awarded to Mr. Maës.

Daguet (Switzerland, No. 75) has exhibited discs of flint glass of $15\frac{1}{4}$, $12\frac{7}{8}$, $10\frac{3}{4}$, $9\frac{7}{8}$, $7\frac{1}{2}$, 7, $6\frac{1}{2}$, and $4\frac{3}{8}$ inches in diameter respectively. On examination, by chords and diameters, they were all found to be good; striæ were suspected to exist in the largest; but, if so, it was in one diameter only, and but to small amount. A disc of crown glass, of 7 inches diameter, and one of $4\frac{3}{8}$ inches, were examined, and found to be good; another, of $6\frac{1}{2}$ inches, was less perfect. The specific gravity of the flint was stated to be nearly 4, and that of the crown to be from 3·5 to 3·6.

Mr. Daguet, by a process of his own, gives to flint glass a degree of hardness not attained by any other manufacturer; his glass, particularly the flint, is in general use amongst all the best opticians, being distinguished both by its homogeneousness and its peculiar property of resisting all decomposition by the action of air. The Council Medal was awarded to Mr. Daguet.

Lenses and Prisms.

Beyerle (France, No. 76[illegible]) exhibits many lenses ground with cylindrical surfaces; they are free from spherical aberration, and give a true view on their whole surface: also long lenses, with the axes parallel, equally true throughout; they are useful in photographic registration of changes in the position of magnets, &c., as adopted by Mr. Brooke.

M. Beyerlé also exhibits lenses ground on curves of different foci, &c.; also many achromatic lenses of short focus. The working of these reflects high credit upon M. Beyerlé, and the Prize Medal was awarded to him.

JAMIN (France, No. 548) exhibits a fine assortment of prisms, chiefly crown; a large flint disc, and plane and concave reflectors, mounted on brass swing frames, of large dimensions. Honourable Mention was made of M. Jamin.

BERTAUD, Jun. (France, No. 1549) has exhibited some of the finest possible Nicholl's prisms; some slices of crystals, prepared to show that, in certain crystallized bodies, heat is unequally transmitted in different directions; with many other specimens of most difficult, yet beautifully-cut prisms, reflecting the highest credit upon the maker. The Prize Medal was awarded to him.

BURON (France, No. 443) has exhibited various prisms.

Lighthouses.

CHANCE (Class XXIV.) has exhibited a design for a lighthouse, consisting of a dioptric apparatus of the first order, and constructed with revolving lenses and catadioptric zones.

This apparatus combines the principles upon which the fixed and revolving dioptric lights of Fresnel were constructed, with an improved method of reflection, by which the use of metal reflectors is entirely superseded.

In the fixed dioptric light of Fresnel, the flame is placed in the centre of the apparatus, and within a cylindric refractor of glass, of a vertical refracting power, the breadth and height of the strip of light emitted by it, being dependent upon the size of the flame and the height of the reflector itself; above and below is placed a series of reflecting prismatic rings, or zones, for collecting the upper and lower divergent rays, which, falling upon the inner side of the zone, are refracted, pass through the second side, where they suffer total reflection, and, passing out on the outer side of the zone, are again refracted. The effect of these zones is to lengthen the vertical strip of light, the size of which is dependent upon the breadth of the flame and the height of the apparatus.

The system adopted by Fresnel, in his revolving dioptric lighthouse, is open to some objections. A large flame is placed in the centre of a revolving frame, which carries a number of lenses, on a large scale and of various curvatures, for the avoidance of spherical aberration. With the view of collecting the divergent rays above the flame, an arrangement of lenses and silvered mirrors is placed immediately over it. By this compound arrangement the simply revolving character of the apparatus is destroyed, as, in addition to the revolving flash, a vertical and fixed light is at all times seen; added to which a great loss of light must be sustained from the use of metallic reflectors.

The lighthouse constructed by Mr. Chance may be described as Fresnel's revolving light, rendered holophotal. It is divided into three compartments, the upper and lower of which are composed respectively of thirteen and six catadioptric zones, which produce the vertical strip of light extending the whole length of the apparatus, and is similar to that described as Fresnel's fixed dioptric light.

The central or catoptric compartment consists of eight lenses of three feet focal length, each of which is the centre of a series of eleven concentric prismatic rings, designed to produce the same refractive effect as a solid lens of equal size. These compound lenses are mounted upon a revolving frame, and transmit horizontal flashes of light as they successively rotate. The motion is communicated to the frame by a clock movement, and performs one revolution in four minutes; consequently, as there are eight lenses, a flash of light is transmitted every thirty seconds to the horizon. The system of a fixed light, varied by flashes from prisms, originated with Fresnel.

The apparatus is lighted by an Argand lamp, with four concentric wicks: it is provided with four sizes of burners, the largest of which is 3¼ inches, and the smallest 1·6 inch in diameter, and is stated to consume 1 pound 10 ounces of oil per hour; carcel oil being employed.

The interior edges of the framework carrying the catadioptric zones are silvered: the workmanship is not characterised by any great degree of finish; a fact in its favour, as any great degree of finish, or adoption of ornament, would involve an increased outlay of capital without compensating advantages.

The glass of which the apparatus is manufactured is dark and of a greenish colour; this we are informed is due to its having been subjected, in melting, to a very high temperature, with a view of draining off the alkali, which, by rendering it dryer and harder, would prevent the exuding of moisture from the surface, a defect to which glass is liable when exposed to the air; it is, however, probable that the colour will have no injurious effect, as it is known that such does not affect the transmission of light. The presence of striæ, which are observable in many points, will, by scattering the rays, cause a loss of light to some amount.

Wilkins (No. 157) has exhibited a revolving catadioptric apparatus for a lighthouse of the first class.

This, also, is constructed upon the holophotal system, and does not differ very materially from that exhibited by Chance. For the moveable cylindrical lenses, is substituted a single revolving cylinder composed of four lenses, alternated with an equal number of fixed ones, according to the succession of flashes to be produced during each revolution. A new arrangement is also introduced by which the friction rollers which revolve on two parallel planes, may be so fitted on an iron axis with regulating screws, that when one part of the plate becomes worn, they may be adjusted to another part. The glass, though white in colour, is not more free from striæ than that exhibited by Mr. Chance; and though great finish and ornament are discernible in the manufacture of the apparatus, it would seem to be rather objectionable than otherwise. For a detailed description, see Illustrated Catalogue, Class VII.

The Jury make Honourable Mention of this lighthouse.

Physical Optics.

Dubosq-Soleil (France, No. 1197) has exhibited Silberman's heliostat. The principle of this instrument is quite different from that of S'gravesandes, which is that of making the perpendiculars to the reflecting plane, describe an oblique cone. In the instruments exhibited, the reflector, by a peculiar gimbal suspension, is always kept equally inclined to two axes, one of which is fixed, and directed towards the line which the reflected ray is to take; the other is kept by a clock motion always parallel to the sun's direction, the plane of the reflected ray being by the same gimbal suspension kept perpendicular to the plane in which both these axes lie, thus the incident ray parallel to the one will be reflected parallel to the other.*

Dubosq-Soleil (No. 1197) has also exhibited a saccharometer. A double gauge is formed by a rotato-polarizing plate of quartz and Iceland spar, of which two semicircles, juxtaposed, and viewed through a telescope of about double magnifying power, are brought to exact coincidence of colour, by turning the spar. In this situation, the images are viewed through an empty tube, closed at either end with glass, and of a given length. The saccharine solution is passed in, and the quality of colour disturbed: the semicircles no longer match: they are then readjusted by sliding one upon the other two achromatized prisms of Iceland spar, acting against each other, so as to leave their difference of thickness outstanding, the amount being estimated in parts of a finely-divided scale, which is graduated so as to show by inspection the saccharine matter present. This is a beautiful and delicate instrument, carefully executed and well finished.

Dubosq-Soleil (No. 1197) has also exhibited Bravais' haloscope, for the exhibition of all the phenomenæ connected with halos, parhelions, &c. This beautiful instrument consists of a clock-movement for the purpose of giving a rapid revolution to a vertical axis; two glass prisms, one hollow for the reception of water; a quadrangular prism, and a small arm carrying a mirror, all adapted for mounting on the vertical axis; two opaque plates of glass for the purpose of obscuring one or two sides of the prisms, as necessary, and a plate of glass mounted. To produce a representation of the parhelion, it is necessary to place a candle in a darkened chamber, on a level with, and 10 or 12 feet distant from the glass prism on its axis of rotation, the prism having two sides covered. On looking in a horizontal direction, the parhelion circle will become visible. By obscuring one side of the prism, only three horizontal lines are seen; two being formed from the exterior and one from interior reflection.

To produce an imitation of the white parhelion, the candle is placed in the same position, and two sides of the prism are again darkened; when on looking at the parhelion circle, at a distance of 120° from the candle, the white one will be perceived.

Coloured parhelions may be exhibited by means of the prism of water, viewed at an angle of 20° or 25°. One side of the prism being obscured, the coloured parhelion, red on the side near the candle, with a white train prolonged to 15° or 20°, will be seen.

To imitate coloured parhelions, formed at a distance of 98° from the sun, the arrangements are the same. By obscuring the prism, and looking at the distance of 98° from the candle, a coloured spot will be observed, red on the side opposite to the candle, and less bright than the parhelion.

The circumzenithal tangent of the arc may be imitated by means of the prism of water, the candle being lowered from its original position, and two sides of the prism darkened; on placing the eye in a proper position, the image will then

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* See Comptes Rendus de l'Académie, 1143, tome xvii., p. 1319.

appear reflected upon the ceiling. Several changes may be produced by simply turning the prism. The circumzenithal arc may be produced by the above arrangement, the position of the eye only being altered.

To imitate the anthelion, it is necessary to make use of the quadrangular prism: its large transparent surface is turned towards the observer, and the candle placed a little above the prism, at the distance of six or eight feet from it. A small circular mirror is then so placed that its centre is on a level with the top of the prism. The eye, being situated behind the prism, will perceive a luminous circle described beneath its edge. If a little slip of paper be placed beneath, it will be perceived more distinctly without *moving*. By moving the position of the eye, several distinct phenomena will become visible. There are means of adjusting the apparatus, to render the image for a time permanently fixed. Other phenomena besides those detailed can be shown by this instrument, and great merit is due to M. Bravais, the inventor.

Dubosq-Soleil, besides these, exhibits a very great variety of delicately-constructed philosophical instruments, for exhibiting the phenomena of polarized light and other physical experiments; such as a cyano-polarimeter, for observing the polarization of the sky; Arago's apparatus for exhibiting the interference of polarized light; Fresnel's screw for polarizing glass by compression; Babinet's goniometer; Brewster's stereoscope, &c. M. Dubosq-Soleil also exhibits an apparatus, invented by himself, for fixing the charcoal points for electric light.

A Council Medal was awarded to M. Dubosq-Soleil.

Spectacles and Opera Glasses.

It is with regret we observe that exhibitors of spectacles in the British portion of the Exhibition have done nothing more than exhibit a collection of shop goods, and have regarded the improvement of the glasses themselves as a matter of little moment. They have vied with one another in mounting spectacles in the finest and most flexible frames, and have produced articles finer and more delicate than any which have before been made. They have, however, with this exception, been content to follow in the steps of their forefathers, and have lost sight of the main object; in their desire to render these useful appurtenances to the sight as little visible and unsightly as possible. In the Foreign Section how pleasing a contrast is afforded by Henri (France, No. 262), who, viewing the subject in the proper light, has possessed himself of a thorough physiological knowledge of the eye, whether healthy or otherwise; and using this knowledge as a basis for the exercise of his skill as an optician, has succeeded in making great advances, and, by a skilful adaptation of the principles of optics, has been enabled to manufacture glasses, the foci of which are so arranged as to suit almost every peculiarity of vision. The glass, itself, is also of great purity, and removes a fruitful source of the uneasiness and fatigue incident upon the use of spectacles.

Upon spectacles, as constructed by M. Henri, we have no objection to report, combining as they do the work of the optician with a knowledge of optics; but we cannot consider we are called upon to report upon spectacle-frames, or articles which have evidently been manufactured and exhibited in a purely commercial point of view.

Rowley (No. 290) has exhibited spectacles of various kinds, chiefly remarkable for their durability of mounting, both as regards material and construction, some being of no greater weight than 11 grains; the whole weight, including glasses, not amounting to more than 2 pennyweights. The steel frames of these last resemble hair lines, and are imperceptible at no great distance.

WEABER (No. 279) has exhibited several pairs of spectacles, many of them distinguished by a mounting of extreme lightness; also a steel hand frame, to be adjusted before the eyes, without pressing upon the nose.

BRAITHWAITE (No. 283) has exhibited several ventilating eye-shades, designed to allow a current of air to circulate freely between the shade and the wearer, and thus to obviate the collection of heated air in the neighbourhood of the eyes.

CHADBURN BROTHERS (No. 259) has exhibited several pairs of elastic steel-framed spectacles, designed to combine lightness with durability, and spectacles for various purposes. These, as well as everything exhibited by Messrs. Chadburn, are remarkable for extreme cheapness, and in this respect they deserve Honourable Mention.

BAYLEY (No. 273) has exhibited various spectacles, in mountings of gold and silver.

HYAMS (No. 278) exhibits a solid piece of glass of a conical shape, or rather of the form of a frustrum of a cone, ground at the base or larger end to a convex surface, and at the smaller end to a concave surface, intended for opera-glasses.

DIXEY (No. 271) has exhibited a variety of spectacles, some of them remarkable for their lightness, a variety of eye-glasses, and several binocular opera-glasses.

CLARK (No. 276) has exhibited spectacles adapted for use, if required, as an opera-glass.

ELLIOTT and SONS (No. 320) exhibit specimens of blue steel and gold spectacles of a very light and flexible kind; also gold hand-spectacles, intended for use with one hand, and various specimens of opera glasses.

HORNE, THORNTHWAITE, and WOOD (No. 220), exhibit Smee's optometer, for ascertaining the refractory humours of the eye, and the required focus of spectacle glasses.

BRAHAM (No. 289) has exhibited various kinds of spectacles.

CALLAGHAN (No. 268), a pair of steel spectacles.

SOLOMON (No. 288), a pair of eye-protectors.

WHITEHOUSE (No. 280), various spectacles; a pair for sketching, mounted without a rim to prevent obstructing the vision.

YEATES (No. 332), of Dublin, spectacles of the ordinary kind.

HENRI (France, No. 262) has exhibited several kinds of improved spectacles, for correcting the defects of vision; those for rectifying obliquity of vision (orthostrabique) are made of steel, bronzed, and furnished with a moveable diaphragm, which may be shifted either right or left at will. They are designed for the cure of squinting, either converging or diverging. Spectacles for both requirements are exhibited.

M. Henri has also exhibited spectacles for preserving the eyesight (conserves gardes-vues); designed for the use of persons suffering from weak eyes, ophthalmia, and particularly adapted for the use of those who work much at night by artificial light.

With the skill of the optician, M. Henri has combined the knowledge of the oculist, and great praise is due to him for the improvements he has made in spectacles adapted to peculiar states of the eye; he has the further merit of being the only exhibitor of such spectacles in the Exhibition. The Jury considered him well worthy of Honourable Mention.

POULLOT (France, No. 966) has exhibited various spectacles in very fine and slender mountings.

As M. Poullot considers a great part of the inconvenience experienced in the use of spectacles is due to the weight of the mounting or frame-work, he has been induced to make various trials for its rectification, by endeavouring to combine stability with the least possible weight. He first contrived a pair of spectacles mounted in steel frames, filled with lead; but the steel proved to be too soft and the lead too heavy. After various attempts he completed several of tempered steel, and entirely without seam or solder, the weight of which did not exceed a quarter of an ounce—a weight in itself insufficient to cause inconvenience to the wearer. The exceeding lightness and comparative elegance of these glasses is designed to remove the prejudice existing against spectacles in general, owing to the reason before mentioned.

M. Poullot considers that he has made spectacles which always preserve the visual ray in the centre of the glass; he has also exhibited metallic woven spectacles for the free admission of air to the eyes, which subdue the light and serve as a screen against dust, insects, &c., or any extraneous substance which might be injurious to the eye.

LEBRUN (France, No. 298) exhibits many very cheap spectacles and opera-glasses.

PRUDENT (France, No. 1412) exhibits a fine collection of opera-glasses, some of which have large object-glasses.

BURON (France, No. 443) has exhibited a number of opera-glasses, both single and double, of which the mountings are of various materials, such as enamel, ivory, tortoiseshell, &c.

BUSCH (Prussia, No. 89) exhibits various spectacles, differently mounted; various single and double opera-glasses, lenses, &c.

LATINIE (Belgium, No. 184) has exhibited various pairs of spectacles.

BAGEN (France, No. 25), spectacle glasses.

PLAGNIOL (France, No. 1679), spectacles of various kinds.

PICK (Russia, No. 170) exhibits a pair of spectacles.

Dissolving View Apparatus.

ABRAHAM and Co. (No. 263) exhibit a trinoptric prismatic lantern. The three lanterns are illuminated by a small circular wick, through the centre of which a tube passes for the purpose of supplying oxygen gas, by which means an intense light is obtained. A disc of 25 feet for each tube may be obtained, and each can be darkened to any extent, without any shadow on the picture. The three discs, by means of the prisms, can be thrown together, or they can be placed at various distances on the screen, forming one panoramic picture.

Abraham and Co. also exhibit a dioptric prismatic lantern, with two discs, which can be used as a dissolving apparatus.

CARPENTER and WESTLEY (No. 270) exhibit a pair of phantasmagoria lanterns; a lantern with the addition of a microscope, together with a set of lenses to be used in conjunction with them; a series of subjects in outline, and various paintings adapted for dissolving lanterns.

HORNE, THORNTHWAITE, and WOOD (No. 220), exhibit a dissolving apparatus for the oxyhydrogen lime light, showing the contrivance for dissolving the pictures; also an oxyhydrogen microscope, and a series of paintings for dissolving views. The novelty of this arrangement consists in the shutters being placed so that they cut off the rays where they cross in front of the lenses, by which means a more perfect dissolution takes place. The quality of the manufacture and the general arrangement of the various parts are good.

Photographic Cameras.

The camera is the principal instrument of the photographist, as by its means light is made to become a chemical agent.

This instrument, the invention of Baptista Porta, towards the end of the sixteenth century, was simply a dark chamber furnished with a single double-convex lens, fitted in a tube, and serving for the focal adjustment of the image. So constructed it was first applied to the copying of different objects, the outlines of which, as given by the camera, were traced upon the paper by a pencil; but the image was reversed. After a time this inconvenience was rectified by the use of a mirror: with an instrument of this kind, A. Canaletti, at the beginning of the eighteenth century, made the drawings for his fine pictures of Venice, which he consequently executed with a perfection of perspective so great as to be regarded as an illusion.

By degrees a lens concave towards the object and convex towards the image was adopted; the picture was thus rendered clearer, but the colours of the spectrum were not corrected. At length an achromatic lens was used, the flint glass being towards the object. M. Daguerre went a step further, and determined those relative proportions of the camera, which, for the most part, are still adopted; the interior being carefully darkened, for the purpose of avoiding casual reflection upon the field of view.

Mr. Ross, in addition, prepares those for portraiture with the greatest intensity yet produced, by procuring the coincidence of the chemical actinic and visual foci. The spherical aberration is also corrected very carefully, both in the central and oblique pencils.

One of the exhibitors of photographs, M. EVERARD BLANQUART, proposed the use of a white chamber, for accelerating the process; but there are serious objections to its adoption, and it therefore is not used.

The object-glasses exhibited are, for the most part, achromatic and double, and consist of two lenses placed at a distance from each other. A photographic object-glass without defect is yet a desideratum.

ROSS (No. 254) has exhibited the best camera in the Exhibition. It is furnished with a double achromatic object-lens, about 3 inches aperture; there is no stop, and no part of the field employed which does not receive plenty of light, so that the corners as well as the middle of the picture are well illuminated. The field is flat, and *the image is very perfect up to the edge.* It has a *revolving* and *adjusting* back-board for the reception of two plates. The same exhibitor has a second camera, furnished with a single achromatic lens of small aperture. The glass of this instrument having been removed, the image could not be examined.

HENNEMAN and MALONE (No. 297) exhibit a camera by Ross. It is furnished with a single object-glass, aperture 4½ inches: the light is admitted through apertures 0·2 in., 0·4 in., 0·8 in. diameter, at about 4½ inches, or at about one diameter of the lens from its surface, the combination being mounted on a brass cone attached to a mahogany plate, which slides and revolves on the front of the box, to allow any given point of the picture-plate to become the centre of the field. The picture-board is 8½ by 10 inches; the focus varies from 10 inches to 17 inches, according to the distance.

KNIGHT and SONS (No. 453) exhibit a camera, the oak stand of which is solidly constructed and pretty firm. It has adjustments for height and azimuth, but not for angular altitude, and has no level. It is furnished with a double picture-plate. The box expands from 9½ to 14 inches. There is no lens, and consequently the image could not be examined. The same exhibitor has a second camera, in a neat, flat, folding, mahogany box, with hinges, which closes up lengthways. It is on a slight, unstable tripod stand, made by cross bracings. The aperture of the object-glass (a single achromatic for landscapes) is about 2¼ inches; the aperture in front of the glass is 0·6 inches, placed at 3½ inches in front of the lens. A projection placed in front of the aperture keeps off stray light. The lens is mounted on a slide to adjust to focus, and its focal length is about 12 inches. No ray can reach the corners of the picture when the lens is brought home, and *only very little light* when out as far as it will go.

HORNE, THORNTHWAITE, and WOOD (No. 220), exhibit a camera with a double achromatic object-glass, whose aperture is about 2½ inches The size of the picture is 8 by 7 inches. The frame allows of two papers being placed in at one time. The box is made to fold together, and is a fine specimen of beautiful, neat, mahogany work, with many good contrivances to keep out light. There is no speciality in the construction of the daguerreotype and calotype apparatus of these exhibitors, excepting a mode of iodizing and bromizing the plates, by sliders of great neatness, the exquisite workmanship of their several articles, and the general arrangements for their use in daylight. Some very fine specimens of chemicals used in the process of photography are also exhibited. A Prize Medal was awarded to Messrs. Horne and Co.

CLAUDET (No. 296) has exhibited cameras: the largest has an aperture of 3 inches in diameter; double achromatic object-glass; when the whole aperture is open, about one-third of the breadth of the lens is cut off on either side, so that only about one-third of the breadth of the picture receives full light from the lens, and the illumination is in consequence very unequal. The image is good and the field is flat.

In Claudet's multiplying camera the multiplying is performed by cross-sliding motions of the picture-plate, performed by two racks, working at right angles to each other, so as to present different parts of the picture-plate successively to the axis of the lens, exactness being secured by the division of the racks into inches and tenths of inches. The camera is short-focussed, to give smal miniature portraits, either presenting the same individual in different aspects, or several grouped together. The object-glass is double achromatic: its aperture is 3 inches, separated by 6 inches on a slide-rack to work in and out of the box; there are no diaphragms interposed. The front of the box carrying the object-glasses opens with a hinge. The tube projects one-eighth of an inch in front, outside of the object-glass, to cut off stray light. The focus is very short, having about 5 inches, extensible to about 8 inches by approach, within limits of motion. By focus is meant the distance of the picture-frame from the hinder surface of the hinder lens.

Willatts (No. 265) exhibits a portable photographic camera with a flexible cloth body instead of a wooden one; it is furnished with horizontal movement, and is adjustable to lenses of various focal lengths; it has also an angular adjustment of the frame of the lenses, the latter for the purpose of keeping the image in the centre of the frame without altering the position of the camera. The size of the photographs is 10½ by 8½ inches. The cloth body of the instrument is mounted by flexible vulcanized caoutchouc bands at each end, and is thus firmly attached to the ends of the camera. The whole instrument is easily taken to pieces and put together, and occupies but a small space. The image was not examined.

Varley and Son (No. 257) exhibit a single reflecting camera. This is a plane speculum with thin edges, placed at an angle of 45°, and designed for making reversed copies of drawings on lithographic stone or wood blocks. It may also be fitted with lenses for enlarging or reducing copies, and for sketching from nature upon the stone. A Prize Medal was awarded to Messrs. Varley and Son.

Abraham, Abraham and Co. (No. 263), exhibit a portable sketching camera, furnished with a meniscus and prism in the place of a lens and mirror. When down, the size of the box is 15 inches in length, 8 in width, and 3¼ in depth.

Plagniol (France, No. 1679). This is by far the largest camera in the Exhibition; the picture-board is 24 inches square, and the object lens is 8 in diameter, double and achromatic. The picture was clear and distinct, as far as unfavourable circumstances would allow of the examination. It is furnished with a clear guard-tube, in front of the object-glass, of 4 inches projection, amply sufficient to cut off side light. The object-glasses are separated by 15 inches, or about double their aperture. The clear space which *all* the object-glass illumines, scarcely exceeds 6½ inches in the centre of the picture; at the edges and corners the defalcation of light is very great. This, however, seems to be unavoidable.

Large as is this camera, it is very far from being the largest that has been constructed. The use of great cameras for copying photographic plates and MSS., especially tables, is becoming common in France. We have heard of some cameras which give pictures nearly a metre in length. A Prize Medal was awarded to M. Plagniol.

Schiertz (France, No. 999) exhibits a camera, the object-glass of which is 2¾ inches in diameter. There is a stop, and the light is so effectually intercepted by the cell and tube of the second object-glass, that the sides of the field are rendered obscure, and the top, bottom, and corners *very* dark; not one-fifth of the central light is effective. The plate for receiving the image is 9 by 7 inches, and the focal distance from the hinder lens about 8 inches; the field is flat, and the image clear and good. The mahogany stand is good, but is not well adapted for taking panoramic views. A Prize Medal was awarded to M. Schiertz.

Harrison (United States, No. 223) has exhibited two or three cameras, but as they are not mounted in boxes, and consist only of the brass-work and lenses, there were no means of trying their performance. They are constructed on the usual principle of double achromatic object-glasses, to give a flat field. The largest is about 4 inches aperture.

Albert (Frankfort-on-Maine, No. 7) exhibits a camera, with a double achromatic object-glass, 5¼ inches clear aperture: there is a slight stop placed between the two glasses, but it cuts off only the reflected light at the sides. The pictures produced are 14 by 11 inches; but the area fully illuminated is only 4¼ inches in diameter, and the corners are very dark. With the full aperture the image in the centre of the field is somewhat imperfect; it will not bear magnifying, and sharp clear definition cannot be attained. Honourable Mention was awarded to Mr. Albert.

Rouget de l'Isle (France, No. 1455). A camera-lucida for copying drawings, by reflection and vision at the same time, through a large vertically-placed sheet of plate glass. The drawing to be copied is laid horizontally on one side of the glass, and the paper to receive the copy on the other; the outlines are then traced by hand with freedom and facility, there being no necessity for using only one eye, or for fixing the position of the head. It is the simplest form of the camera-lucida. It inverts right and left; but this may be obviated in some cases by a looking-glass. The adjustments are easy and simple. Honourable Mention was awarded to M. Rouget de l'Isle.

Photographic Glass.

Messrs. Chance and Co. (Class XXIV. No. 22) have exhibited flint glass, in discs and in plates, adapted for the construction of object-glasses for Daguerreotype and Talbotype apparatus and cameras. Of these discs one is as large as 20 inches in diameter, and there are some thin plates of the same kind of glass for cutting up.

The density of this glass is 3·20; the index of its refractive power is 1·60.

Buron (France, No. 443) has exhibited a collection of glasses of 6, 8, 10, and 12 inches diameter, for dissolving views.

Photography.

Rapid as have been the discoveries connected with photography, and great the improvements since the invention of M. Daguerre, there is yet much to be done to enable it to rank amongst the sciences of the age. It holds a place at present intermediate between an art and a science, a position eminently favourable to development in either direction. Its pursuit, as an elegant and most extensively useful art, affords a strong motive for inquiry and experiment in the improvement of its processes, in the course of which an infinity of facts, new and unexpected, come forward, every one of which may turn out to be the embodiment of some pregnant scientific principle; nay, even the smallest minutiæ of manipulation on which it is found that success or failure in the production of artistic effect depends, may, if duly observed and reasoned on, afford indications, linking together the known and the unknown in optical science, and tending to bring these mysterious operations of light within the pale of exact reasoning. On the other hand, science is too much in the habit of repaying to art with interest every assistance of that nature, to leave room for doubt of similar results in this instance, when once the principles of operative chemistry shall have assumed a definite form and subjective connection. It is this which affords us full assurance that photography is yet in its infancy, and that all which has been yet accomplished—marvellous and exquisite though it is—is as nothing to what will be performed when the veil shall be removed, which for the present obscures its true scientific principles. In this view the photographic study of the prismatic spectrum *per se*, apart from all artistic combinations and coloured media, cannot be too strongly recommended to experimenters, and we lament to observe in the whole Exhibition only one instance (that of M. Claudet) in which this study appears to have been in any way followed up, so as to afford *exhibitable* results. Mr. Ross is understood also to construct the object-glasses of his photographic cameras, with especial reference to the excessive development of the actinic spectrum beyond the luminous one in the direction of the violet rays. When bromine is used in the preparation of the plate or tablet, it may be questioned how far this is really an improvement. Should means be discovered of truly representing the colours of objects, and limiting the action to the luminous ray, the conditions of achromaticity for the photographic camera will be the same as for the telescope.

The fine collection of photographs now exhibited will tend much to the advancement of this beautiful art, by showing us what has been done, and also indicating that which is necessary yet to do, and will doubtless prove an era from which to date many improvements.

Since the epoch when M. Daguerre and Mr. Talbot first divulged their respective processes for impressing photographic images on silver and on paper, scientific men both at home and abroad have by their increasing researches and improvements brought photography to a degree of perfection, which, however short of what it may one day acquire, yet seems incredible, considering its brief existence. Perhaps its advance cannot be more strongly proved than by the fact that the method, at first adopted a very few years since for procuring daguerreotype portraits, required that a person should sit without moving for twenty-five minutes in a glaring sunshine. The improvement as shown in the almost instantaneous process of the present day is most striking.

It is not the object of this report to trace the history of inventions, nor to decide points of priority, especially in a subject which has received accessions from such innumerable quarters, and called into action the skill of so many eminent chemists and photologists of every nation. Suffice it to say, that after the introduction of M. Claudet's accelerating process by the application of chloride of iodine and chloride of bromine (an invention which he liberally gave to the public through the medium of the Royal Society and the Académie des Sciences), the daguerreotype process, as publicly practised, became reduced to some system, and two daguerreotype establishments were formed in London. The portraits taken at this time were, however, deficient in expression; but in spite of all deficiencies, the receipts of these establishments several times amounted to 60*l.* in one day.

At a somewhat later period that remarkable variety of the Talbotype process, designated by its inventor by the name of Calotype, was also publicly employed for the production of portraits by Mr. Collen: the artistic effect in these representations was susceptible of being much heightened by the brush, and the defects of expression might be removed, and the likeness in consequence greatly improved by one or more subsequent sittings.

M. Claudet, who, from the earliest time of the daguerrian invention, displayed great genius and ability in perfecting the various processes, first perceived the necessity of aiding the artistic effect of his representations by subsidiary adjuncts of a different kind. He it was who first practised the placing of painted backgrounds behind the persons whose portraits were to be taken. Thus an infinite variety of scene might be afforded by the operator simply providing himself with a few subjects skilfully adapted to the requirements of the occasion. To him also we owe that extremely pleasing adaptation of mechanical adjustments for bringing many miniature representations of the same individual under different aspects, to be impressed in regular compartments of the same plate and framed together, of which we find specimens exhibited in his collection.

It is not necessary to detail step by step the successive improvements in the different processes and apparatus for daguerreotypic photography, though we may mention that to the exertions of Messrs. Claudet, Gaudin, Fizeau, and Draper, the public are indebted for many improvements. To M. Fizeau is due the reproduction of the proofs of electrotype; also a new process for engraving the daguerrian image, and of preserving that image from destruction by gilding the surface.

The Exhibition presents many fine calotypes, or as they are sometimes called in the Catalogue sun-pictures, for the production of which the preparations of Mr. Talbot hold the first rank. M. Bayard, also, has been celebrated for his achievements in this line, and has contributed many splendid proofs obtained on various sensitive papers. Mr. Talbot has himself exhibited nothing; but many of his productions will be recognized among those exhibited by Henneman and Malone, as adapted to the practical wants of travellers, collectors, &c. This branch of the art offers inestimable advantages, viz.: 1st, That the papers may be prepared at leisure some time before an occasion for using them arrives; 2ndly, That when pressed and fixed, they may be carried without injury in a portfolio, like other drawings; 3rdly, That from one good negative original any number of positive copies may be taken, to the extent, indeed, of two or three hundred copies in a *rainy day*, as proved by the practice of M. Everard Blanquart (France, No. 1551), and supplied to the public at a cheap rate; 4thly, That they may be wholly obliterated so as to reduce them apparently to the original condition of white paper, and carried about in that state for an indefinite period, though susceptible of revival at any instant. Considering it probable that the following communication, addressed by M. Arago to the Academy of Sciences, on the granting a national recompense to M. Daguerre, may be as useful to a portion of the public now as then, it is subjoined in the words of M. Arago himself:—

"A short time after the law was voted, granting a national recompense to M. Daguerre, some opinions, which in my idea were very erroneous, were entertained by a small portion of the public, which rendered it necessary for me to show that the discovery, newly made, was not to be estimated in respect to art only, but to the very valuable subjects for investigation which it presented in reference to the physical sciences."

Without further remark we proceed to the discussion of the photographs exhibited.

Daguerreotype Pictures.

CLAUDET (No. 296) has exhibited a large collection of daguerreotype portraits, both plain and coloured. Amongst various excellencies of which they are possessed, we may particularly mention that of their *non-inverting*. This is a great improvement, and by it M. Claudet has annulled the superiority which the sun-pictures have long possessed in this particular over the daguerreotypes.

On examining the uncoloured specimens exhibited by Claudet, it will be found that they are distinguished by artistic arrangement, judicious distribution of light and shade, and great clearness of definition. The general tone is good, M. Claudet having uniformly avoided violent contrasts of light and shade, a circumstance to which much of his success may be attributed. In this collection are several female portraits in white draperies, which pictures deserve commendation for their beauty of detail and freedom from solarization. Many of the above remarks apply equally to the coloured specimens, most of which are portraits, and are distinguished by careful and harmonious colouring, the focus having been so judiciously selected, that most of them present an artistic and natural appearance, seldom hitherto obtained by daguerreotypists.

Photography may be said to be too faithfully exact in its results for the purposes of art, detailing as it does the accessories in the background and the main object of the group with equal fidelity. When blending colour with photographic works, or in visibly uniting art and science on the same plate, the operator should be possessed of knowledge and feeling sufficient to know the proportions in which art and science should intermingle so as to be subservient to each other: in this knowledge, which is chiefly dependent upon the proper focal adjustments of the picture, M. Claudet excels; and the admirable manner in which he sacrifices the details afforded him by science to the requirements of his subject, is the result of long and laborious investigation.

An uncoloured daguerreotype by Claudet is worthy of particular mention; it represents various articles of virtu, pictures, &c., grouped together: the perfect focus of each part and general relief of the whole prove it to be a successful application of his focimeter.

M. Claudet also exhibits the dynactimometer* and focimeter. He also exhibits the effects of the spectrum on the daguerreotype plate, as prepared by him, and a variety of curious and instructive specimens illustrative of the different refrangible rays. The Council Medal was awarded to M. Claudet.

KILBURN (No. 294) has exhibited a case containing several carefully-selected specimens of coloured daguerreotypes. The subjects of these pictures are confined to groups of figures of small size, and are very brilliant and elaborate in their details, too much so for artistic effect. For novelty of design we may mention a

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* The reader is referred for an account of the dynactimometer to the Reports of the British Association, August 1850, and to the Philosophical Magazine, June 1851, and for the focimeter, to the British Association Reports, September 1849, and Philosophical Magazine, November 1849.

small picture of the interior of a room, including a whole-length portrait of Jenny Lind: beside, and near her, is a large mirror, in which the figure is reflected. That the reflection in the glass is equally perfect with the original is the point worthy of remark and commendation. Towards the centre of this case is a plain daguerreotype portrait of the Queen. The finish and execution of this little work are very great. The Jury awarded a Prize Medal to Mr. Kilburn.

MAYALL (No. 291) has exhibited in this department a large collection of daguerreotypes, uncoloured. They are characterized by great contrasts of light and shade, disposed in large masses. Amongst the subjects exhibited are four tableaux from the "Soldier's Dream," and several groups from Nature, variously arranged. Mr. Mayall's strong and broad masses of light and shade are better adapted for landscape scenery, of which the Falls of Niagara is a favourable specimen. His Bacchus and Ariadne, 24 inches by 15, is, perhaps, the largest *daguerreotype* which has yet been executed. The difficulty of duly preparing so great a surface must be extreme. He has also exhibited a crayon daguerreotype, produced by a process of his own invention.*

BEARD (No. 292) has exhibited a case of daguerreotypes, some of them enamelled, according to a process invented by himself.†

LAROCHE (Class XXX., No. 252) has exhibited three small daguerreotypes: two are coloured: the third, a group of statuary, is good.

VOIGTLANDER and EVANS (Class XXX., No. 254), Knightsbridge, have exhibited coloured daguerreotypes.

Of the remaining exhibitors in England,—GRIFFITHS and LE BEAU (No. 404) have exhibited a case of daguerreotype miniatures, coloured; PAINE (No. 295), a series of photographic pictures, intended to show the processes of the art; TYREE (No. 299), coloured daguerreotype portraits; and CRADDOCK (No. 227), photographic copies of various engravings.

On examining the daguerreotypes contributed by the United States, every observer must be struck with their beauty of execution, the broad and well-toned masses of light and shade, and the total absence of all glare, which renders them so superior to many works of this class. Were we to particularize the individual excellencies of the pictures exhibited, we should far exceed the limits of space to which we are necessarily confined. Where all is good, it follows that remarks must be restricted to peculiar excellence alone.

Before speaking of the several works exhibited, it is but fair to our own photographists to observe, that much as America has produced, and excellent as are her works, every effort has been seconded by all that climate and the purest of atmospheres could effect; and when we consider how important an element of the process is a clear atmosphere, we must be careful not to overrate that superiority of execution which America certainly possesses.

LAWRENCE, of New York (United States, No. 151), has exhibited several daguerreotype portraits, uncoloured. They are remarkable for clear definition and general excellence of execution. In this series two large portraits of General J. Watson and W. Bryant, Esq., each of which measures 12½ inches by 10½ inches, deserve particular commendation Notwithstanding their large size, they are

* See the Illustrated Catalogue, and the Athenæum for 1850, p. 1048.

† See the Illustrated Catalogue, note ii., p. 428.

throughout perfectly in focus, and are beautifully finished in all their details. These are two of the best pictures in the American collection. A portrait of General J. W. Wells, and of a lady in a black silk dress, of a smaller size, are also remarkable. A Council Medal was awarded to Mr. Lawrence by the Jury, but not confirmed by the Group.

BRADY (United States, No. 137) has exhibited forty-eight daguerreotypes, uncoloured. These are excellent for beauty of execution. The portraits stand forward in bold relief, upon a plain background. The artist having placed implicit reliance upon his knowledge of photographic science, has neglected to avail himself of the resources of art. The portraits of General Taylor, Calhoun, General Cass, and James Perry are strikingly excellent; but all are so good that selection is almost impossible. The Jury awarded the Prize Medal to Mr. Brady.

WHIPPLE (United States, No. 451) has exhibited several specimens of daguerreotypes, amongst which one of the moon may be mentioned with the highest commendation: this is, perhaps, one of the most satisfactory attempts that has yet been made to realise, by a photographic process, the telescopic appearance of a heavenly body, and must be regarded as indicating the commencement of a new era in astronomical representation. The same exhibitor has included in his collection three pictures, containing several full-length figures, well grouped, and artistically arranged. Each part is well in focus, and the definition is admirable. An agreable tone pervades all of these pictures. A Prize Medal was awarded to Mr. Whipple.

MAYALL (United States, No. 491) has contributed largely to the American collection; these works being characterized by the same broad masses of light and shadow as those which he has exhibited in the British department (No. 291). The subjects of the pictures in the present series consist chiefly of small groups and portraits; also two cases containing illustrations of the Lord's Prayer. The majority of these (most of which are uncoloured) are effective, verging upon the theatrical in point of style, but are not all equally well defined. We should be doing Mr. Mayall an injustice, were we not to mention as a brilliant exception to the above criticism, a small figure of a female reclining: it is exquisite in delicacy of execution, harmonious distribution of light and shade, and an admirable tone pervades the whole picture; this the finest of Mr. Mayall's contributions is free from colour, and is daguerreotyped from a classic work of art. The Jury awarded Honourable Mention to this exhibitor.

EVANS, New York (United States, No. 105), has exhibited several portraits of great merit. Those of the Rev. — Ingersoll, Dr. Nott, Dr. Lord, and Dr. Shelton, are characterized by peculiar excellence; also two portraits, each of a lady sitting near a table upon which a group of flowers is displayed, deserve to be noticed as fair specimens of the perfection to which this application of science to the purposes of art has been carried.

MEADE BROTHERS (United States, No. 109) have exhibited a series of portraits of more than ordinary size. Conspicuous amongst this collection are the heads of Wallack and H. W. Meade. The modulation of light and shade upon these last is admirable, as well as the details of the features, and the total absence of all harshness: the artistic effect is excellent. Greater credit is due to this collection of portraits, than to the series of allegorical subjects exhibited by Mr. Meade.

Pratt, Richmond, and Co. (United States, No. 264), have exhibited several daguerreotypes, of various degrees of excellence. The profile of an old man, assisted by colour, is the best.

Whitehurst, Virginia (United States, No. 377), has exhibited twelve views of the Falls of Niagara. These are admirable, and possess a degree of reality not always attained in landscapes produced by the daguerreotype process.

Amongst the remaining exhibitors of daguerreotypes in the United States department are—

Gavit (United States, No. 125), Root (United States, No. 42), Whitehurst (United States, No. 325), and Hogg (United States), all of whom have exhibited daguerreotypes, but not distinguished by any striking degree of excellence. Langenheim (United States, No. 62), has exhibited two large talbotypes, one of which is a panoramic view of Philadelphia, executed in compartments, but wanting unity of effect. This artist, also, exhibits a series of subjects on glass, designated by him under the name of hyalotypes, being delicate miniatures, excellently adapted for magic-lantern subjects. The material would appear to be collodion, albumen, or some similar preparation, forming a film on the glass, capable of receiving the impression. A daguerreotype view of Cincinnati, by Fontyne and Porter (United States), is more successful. This is also taken in separate compartments: it is clear and good in colour, and forms an effective picture. Harrison (United States, No. 491) has also some daguerreotypes of a very superior description.

In turning our attention to France we find several daguerreotypes, which, in contradistinction to those of America, are characterized by large masses of light, in which is expressed the greater amount of detail and minutiæ. They are not so entirely free from glare as those of America.

Thierry (France, No. 1038) has exhibited eight daguerreotype views of Lyons; they have a sunny look, and are very brilliant, but are wanting in artistic effects of light and shade. A portrait of M. Thierry himself deserves particular commendation, and is far superior to the above-mentioned pictures. The Jury considered this exhibitor as deserving Honourable Mention.

Maucomble (France, No. 620) has exhibited a case of very highly-coloured daguerreotype portraits. They are excellent, but possibly belong more to the fine arts than to photographic science. It is difficult to say whether the harmonious and rich colouring of the French school, as applied to these portraits, or the masterly blending of the colour and daguerreotype, deserve most commendation. Art is here engrafted on science, the latter being merged in the former, and the impression left on the mind is that naturally produced by the view of a beautiful artistic production. They are charming, but we repeat belong more to art than to science. The Jury have awarded these works Honourable Mention.

Sabatier (France, No. 1467) exhibits a single daguerreotype portrait of large size (8 inches by 6), which is every way excellent. It is entirely free from glare (to which its low position contributes not a little, the light coming from above), and in expression, freedom from constraint, and perfect representation of texture, may rank with any single piece in the Exhibition.

Plaignol (France, No. 1679) exhibits daguerreotypes rather as specimens of the production of his large camera (though not of the full size which that instrument is capable of producing), than as claiming especial distinction in this particular department of art.

Gouin (France, No. 241) exhibits a series of coloured daguerreotypes, which, however, want brilliancy and purity of colour; the backgrounds are also out of focus. An uncoloured portrait, 7½ inches by 6, does better justice to the powers of this exhibitor.

Kohnke (Hamburgh, No. 103) and Von Minutoli (Prussia, No. 191) have exhibited daguerreotypes.

Vogel (Austria, No. 739) exhibits daguerreotypes, to which Honourable Mention was awarded by the Jury.

Talbotypes—Calotypes—Sun-pictures.

Buckle (Class XXX. No. 301), of Peterborough, has exhibited a great many calotype pictures, all of which are characterized by great delicacy of tint and exquisite *cleanness* of execution, and deserve to be ranked amongst the finest specimens of photography in the Exhibition. The process adopted by Mr. Buckle, he has described at some length; it is not subjoined here for want of sufficient space, but the beauty of Mr. Buckle's calotypes sufficiently testify to the superiority of his method. He observes that, with regard to the adjustment of the focus, no rule can be laid down; but having himself a knowledge of art, practical as well as theoretical, he applies it to the arrangement of the subject and to deciding on that point of the picture best calculated to be put into focus. The size of the aperture of the lens, as also the time of exposure, are so much matters to be decided on at the time of taking the picture, as to render the laying down a rule next to impossible. The paper employed, Mr. Buckle observes, is made by Mr. Turner, of Chufford Mills, and is, he considers, unequalled. Mr. Buckle's negative originals, it should also be observed, are *on paper*. He does not employ the albuminous process. A Council Medal was awarded to Mr. Buckle.

Ross and Thomson (Class XXX. No. 299) have exhibited several beautiful talbotype pictures, consisting of views from nature, interiors, groups, &c., and are the only exhibitors in the British section of photographs by the albuminous process, which in practice they appear to have carried to a high state of perfection, and have not only substituted it for the old method of taking the negative proofs on paper, but have in more than one instance exhibited the positive proof upon the albuminized glass itself. In addition to the great clearness observable in the details of their landscape scenery, and the great delicacy of their delineation of objects in general, we may take notice of the excessive beauty of the tints which their works exhibit; not only are the shadows deep and Rembrandt-looking where suitable to the effect required, but the middle distances display a beauty of colour nowhere equalled excepting in the very superior works by M. Martens, in the French department.

As an illustration of the variation of tints which these works present, in contradistinction to the fine Vandyke brown and deep shadows, we may mention a small picture (a group of statuary), the peculiarity of which consists in the colour, which is blue, an effect produced by taking the negative proof on albuminized glass, and rendering it positive by repeated washing in hyposulphate of soda, the proof being originally laid upon a black ground. By this process the whites become black, and *vice versâ*. The hyposulphate of soda is a most useful agent in the colouring of both negative and positive proofs, and affords a vast range of beautiful tints of inexhaustible richness; but it is difficult of application, and is available only in the hands of a skilful operator.

The coating of the glass with albumen is a difficult operation: the method adopted by Ross and Thomson differs from the French process (which is due to M. Niepsce, and is usually called the "albuminous process"), consists in pouring a quantity of albumen on the plate and resolving it over a slow heat, for the purpose of insuring its even distribution. As shown in the practice of those exhibitors, this method would seem to be perfectly successful; and indeed the beautiful and extreme delicacy and variety of tint, the aërial perspective by which the background is made to recede by imperceptible gradations into the horizon, all amply attest the powers of Messrs. Ross and Thomson.

A number of talbotypes, also exhibited, display equal variety of tint, and a depth and richness of tone without any straining for effect.

A Council Medal was awarded to Messrs. Ross and Thomson.

HILL and ADAMSON (Class XXX. No. 300) have exhibited very many talbotype groups, remarkable for easy and graceful arrangement. They are in effect after Rembrandt, being made out in broad and deep-toned masses of light and shade. As a whole, they are very sketchy and spirited. The tints are rich and varied both in depth and colour, and are of a rich sepia. They have received Honourable Mention from the Jury.

HENNEMAN and MALONE (No. 297) have exhibited talbotypes on paper, consisting of copies of small intaglios, portraits, both plain and coloured, and various small groups, &c. These are all natural and pleasing, and great delicacy is observable in the lights and shades, the tone of which is a fine warm sepia brown. The greater part of these pictures are small portraits; one, however, which is 8 inches by 6½, is very good, and evenly illuminated. The coloured portraits in this collection are very good, and no little credit is due to the artistic skill which they display.

Messrs. Henneman and Malone also exhibit specimens of the cyanotype and chrysotype processes of Sir J. Herschel, the chromotype of Mr. Hunt, and talbotypes tinted by the application of caustic potash and a lead salt. A Prize Medal was awarded by the Jury to Messrs. Henneman and Malone.

COLLS, R. and L. (No. 303) have exhibited several sun-pictures on paper. They are rather blotty in appearance, but are good in colour. Views of Windsor Castle and Stoke Church deserve high commendation.

HARMER (Class XXX. No. 298) has exhibited two calotype pictures, one a landscape: the reflections as shown in the water are excellent. The fluctuation of the reflections caused by the ripple of the water is very beautiful, and true to nature. The execution of the picture is good, and the tints are clear and delicate.

OWEN (No. 670), of Bristol, has exhibited a series of calotype pictures, most of them landscapes and wood scenery. They want clearness of definition, being somewhat black and heavy. Mr. Owen states himself to have been able to execute in a single day, in a journey of 300 miles, ten large-sized talbotypes of local scenery, each paper being prepared on the spot. The preparation is greatly facilitated by a glass spreader, of his own invention, by which the solutions are evenly applied.

Collie (No. 271), of Jersey, has exhibited a frame, containing several calotype pictures, chiefly portraits and domestic scenes. These are not all equally good; many of them are blotty and wanting in depth.

Rippingham has exhibited several talbotypes, being a series of untouched positives, from collodion negatives, on plate glass. He also exhibits other photographs from paper negatives, but they are blotty and want more light.

Bingham (Class X. No. 302) is an exhibitor of talbotype pictures, landscapes chiefly. Being near objects, such as cottages, trees, &c., there is no room for aërial perspective. They are very cleanly executed.

Field and Son (No. 250) have exhibited calotypes.

Martens (France, No. 610) has contributed several large and beautiful photographic proofs, on glass and paper, obtained by an apparatus made by Lerebours and Secretan; also several large photographs from negatives on glass, five of which (views of Notre Dame, the Louvre, and St. Germain-de-l'Auxerroy), measure 12 in. by 9½ in., and are pre-eminently beautiful. Two pieces of sculpture, from the Arche de Triomphe, Barrière de l'Etoile, call forth the highest admiration. One of these groups contains seven full-length figures, together with their accoutrements, in a space of 3½ in. by 3 in.: the great finish and beauty of execution here displayed has never been excelled. Space does not permit us to individualize all M. Martens' works, most of which are equally good, such as the ceiling of the Louvre, the Chateau de Vincennes, &c.; but we may say that for richness of effect and perfection of definition, they are the finest specimens which it seems possible to produce, exhibiting as they do a most successful combination of careful execution, delicacy of colour, and great artistic merit. No trace of the brush is visible. A daguerreotype view of Paris, by the same exhibitor, is good, and evidently not retouched. A Council Medal was awarded to M. Martens.

Bayard (France, No. 414) has exhibited several sun-pictures, the subjects of which are chiefly selected portions from the public buildings in Paris. One of the cases exhibited by M. Bayard contains five pictures, all excellent; though to the Bibliothèque de Louvre we may give the preference for its judicious arrangement of light and shade and elaborate representation of detail. The interior of a church is deserving of separate mention; the figures, which are numerous, are admirable, and their perfect delineation, even when remote from the eye and in deep shadow, is worthy of commendation. Also a calotype of Venus and Cupid, from a bas-relief, is worthy of mention, owing to the beautiful tint which pervades the picture. In M. Bayard's representations of sculpture, the difference of surface and texture between the plaster cast and marble statute is marked with perfect distinctness. A Prize Medal was awarded to M. Bayard.

Flacheron-Hayard (France, No. 836) has exhibited several sun-pictures of ruins in Spain, Rome, and Paris. These are all excellent; the colour is good, and the artistic effect admirable. They appear to be possessed of nearly equal merit. The Arch of Titus deserves especial mention for the perfectly-artistic expression of the whole, combined with a singularly-accurate representation of the superficial texture of the material. A Prize Medal was awarded to M. Flacheron.

Le Gray (France, No. 585,) has exhibited several sun-pictures. Some of these are good, but many are heavy and wanting in detail. These pictures vary in tint, from sepia to olive citrine.

HENRI LE SECQ (France, No. 592) has exhibited several calotypes; the subjects are architectural. These pictures may be mentioned with great commendation as regards their photographic finish; but nearly all of them exhibit a degree of negligence in adjusting the visual axis of the camera to the true horizontal direction, which, by making all the vertical lines of the buildings *visibly convergent* in the picture, contravenes the rules of perspective, and produces an effect highly unpleasing. This is the most common fault of photographic representation by the aid of a camera, and it is right to notice it to put artists on their guard. Every photographic camera ought to be provided with a small spirit-level to secure this adjustment in the field, independent of trial.

EVRARD, BLANQUART (France, No. 1551), has exhibited several talbotype pictures, the positive proofs being obtained by a process which admits 200 or 300 impressions to be taken from the same negative proof; the price varying from five to fifteen centimes, according to the size. These are not wholly successful; several of the pictures are dark and blotty, and somewhat resemble engravings taken from a worn-out plate.

COUSIN (France, No. 1572) exhibits a series of positive talbotypes, from negatives on paper, in all seven subjects, six of which are of exquisite beauty.

ALBERT (No. 7, Frankfort-on-the-Maine) has exhibited sun-pictures of large size, but they are fuzzy, being ill defined and void of effect. Two specimens of smaller size, one of them coloured, are good.

CHEVALIER (France, No. 1729) exhibits some photographic proofs.

MAYER (France, No. 622) has a series of miniatures, coloured on talbotype grounds. They are of exquisite beauty, and give the idea of perfect likenesses; but the use of the brush being obvious, they are rather to be regarded as works of art than science.

PRETSCH (Austria, No. 362) has exhibited several large photographic pictures from nature. The subjects are various, comprising groups of statuary, architectural buildings, landscapes, &c. The subjects are well chosen, and show good execution and artistic management. Mr. Pretsch was awarded the Prize Medal by the Jury.

In closing our remarks on this department of the Exhibition, we may be permitted to record some degree of disappointment at the absence of specimens of the application of photography to any department of representation, other than such as please the eye or administer to personal feelings. As regards its application to an infinity of useful and instructive purposes, we have literally nothing! We find, for instance, no specimens of copies of ancient inscriptions (a few incidentally occurring on the Roman ruins perfectly familiar to every one, only excepted)—no delineations of tropical or remote scenery—no specimens (for the single exception of Claudet's spectrum is hardly to be cited) of the actinic spectrum on chemical preparations, or on natural vegetables or animal colours—no impressions of the lines in the photographic corresponding to those in the luminous spectrum—no magnified representations of the microscopic products of nature, or of the dissected parts of plants or animals—no copies of pages of ancient manuscripts—no miniatures of printed books (holding out the promise of future publications in miniature), or that of condensing in volume for preservation in Museums,*

* We are informed that a catalogue of the National Library of Paris, in which the photo-

&c., the enormous mass of documentary matter which daily more and more defies collection from the mere impossibility of stowage, but which will one day become matter of history—and a thousand other applications which it would be tedious here to mention.

Connected with photography, we may also notice the absence of any specimens of scotography, or the art of copying engravings by simple juxtaposition in the dark by obscure inter-radiation, invented by Moser.

Magnets.

Exhibitors of magnets are few in number; among them Logeman (Netherlands, No. 87) and Henley (England, No. 428) have exhibited the most powerful steel magnets: it is satisfactory to learn that both these exhibitors are still applying themselves to their further improvement.

Hearder (No. 439) deserves especial notice for the attention he has paid to ascertain the receptive and permanent magnetic powers of cast iron, both in separate plates and in their combinations.

As early as the year 1832, Dr. Scoresby commenced a series of experiments on the magnetic properties of cast iron, but which, owing to the thickness of the masses employed, did not yield decisive results. Prior to the year 1844, he repeated his experiments upon different kinds of cast iron, and found that "cast iron possesses considerable powers of magnetism, both in capacity and retentiveness, though greatly inferior in both qualities to those of properly-hardened steel, with several other interesting results."* The general results found by Dr. Scoresby, though calculated to show the unsuitable character of the specimens and forms of the cast iron employed by him to general magnetic purposes, yet were of such an encouraging nature, as to lead to the hope that more important results might be obtained by the employment of cast iron in larger masses, and in different forms.

Mr. Hearder was led, in the course of his experiments, to consider that cast iron had not been subjected to a sufficient variety of tests, and he was still more confirmed in this opinion, by observing how its mechanical properties varied, according to the temperature of the different kinds of iron, and concluded that the conditions which acted against its being used as a bar magnet might be made available for one of the hore-shoe form. In 1843, he made the magnet now in the Exhibition, which is still possessed of considerable power, as determined by the Jury.†

The following are the particulars of the magnets exhibited:—

LOGEMAN (Netherlands, No. 87) has exhibited the most powerful permanent magnets in the Exhibition.

The following are the results of the experiments:—

One whose weight was 1 lb. 0½ oz. carried a weight of 16 lbs. 9½ oz.

One whose weight was 6 lbs. 0½ oz. carried a weight of 66 lbs. 3½ oz.

One whose weight was 101 lbs. 12 oz. carried a weight of 436 lbs. 12 oz.

A Council Medal was awarded to Mr. Logeman.

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graphic fac-simile of the title-page of each work, in miniature, is registered, is actually in progress.

* See Scoresby's Magnetical Investigations, Part II., chap. viii., pp. 330—347.

† It was described in the Electrical Magazine, October, 1845, vol. ii., p. 137.

The exhibitor of the next best magnets was Henley (No. 428), and the results of the experiments are as follows:—

A magnet weighing 2 lbs. 5 oz. carried a weight of 31 lbs. 5½ oz.
A magnet weighing 8 lbs. 4 oz. carried a weight of 56 lbs. 14 oz.
A magnet weighing 32 lbs. 6 oz. carried a weight of 120 lbs. 4½ oz.

Shaw and Son, Sheffield, exhibited several magnets:—

One whose weight was 7 oz. carried 4 lbs., and
One whose weight was 76 lbs. 0¾ oz. carried 61 lbs. 7½ oz.

Hearder (No. 439) has exhibited a cast-iron compound horse-shoe permanent* magnet. This magnet was constructed with a view to its being applicable to every purpose requiring high magnetic power. It consists of 24 plates, 2 inches wide, and 0·19 inch thick, cast in the form of a horse-shoe, which is 16·75 inches in length. The 24 plates are strongly fastened together; the poles, which are distant from each other 1·25 inches, are capped with soft iron, for the purpose of concentrating the magnetic power, at the same time, it renders the grinding of the poles unnecessary.

The construction is simple. The bars being made of iron, hardened as much as possible, require no preparation to adapt them for magnetization.

The economy of construction, as compared with a steel magnet of the same dimensions, is estimated as 4 to 1.

It is designed to be made available for the construction of electric machines for telegraphic, or electro-chemical purposes, and was manufactured at Mr. Hearder's establishment at Plymouth.

Mr. Hearder observes that, whatever be the relative powers of the plates previously to their being put together, as a mass they are found to undergo a considerable change; the two external magnets having their poles slightly reversed, the two next being neutral, and the rest having direct polarity, being strongest in the centre, and gradually diminishing towards the two external plates. On testing the individual powers of each magnet, after their several combinations for three years, the sum of the whole was less than 15 lbs., whilst collectively they were capable of lifting a weight of more than 100 lbs.

Other particulars concerning this magnet are to be found in the Report of the Royal Cornwall Polytechnic Institution for 1850.

This magnet was found to weigh 71 lbs. 8 oz., and to carry a weight of 120 lbs. 9 oz.

Mr. Hearder has exhibited a powerful horse-shoe permanent steel magnet, intended for all purposes requiring high magnetic power.

It is composed of a large number of wide and extremely thin horse-shoe plates, cut out of thin sheet steel, tempered and hardened sufficiently to admit of their being flattened with a hammer. The magnet weighs 39 lbs., and Mr. Hearder says will support nearly 250 lbs., with a round-faced keeper. It is intended for magneto-electric purposes, where great power is required in a small space. This magnet was found to weigh 39 lbs., and to carry a weight of 112 lbs. 9 oz.

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* These magnets are termed permanent, in contradistinction to the temporary electro-magnets.

Rundell (No. 438a) exhibits a carbonized cast-iron magnet; the carbonization having been performed by prussiate of potash and oil. This magnet is offered as an improvement on Mr. Hearder's cast-iron magnet, as shown at the last Polytechic Exhibition. On trial, this magnet was found to weigh 27 lbs. 8 oz., and to carry 35 lbs. 9 oz.

Magnetical Instruments.

Brooke (No. 144) exhibits photographic apparatus for the self-registration of the changes of position of the declination magnet, of the horizontal-force magnet, and of the vertical-force magnet.

The three magnets are so placed that the residual effect of each pair upon the third is a minimum, which is to be determined by experiment.

The principle is the same for all, viz., wrapping prepared photographic paper around a cylinder whose axis is placed parallel to the direction of movement to be registered, and which is turned round uniformly by clockwork.

The light, from a gas lamp, passes through a small aperture placed near it, and falls upon a concave mirror of speculum metal, which rests in a stirrup firmly connected to the magnet, so that it partakes of all the angular movements of the magnet. The pencil of light is then deflected from the mirror to a plano-convex lens, placed parallel to the axis of the cylinder and near to it: this lens condenses the line of light to a definite spot of light on the paper. This spot of light, therefore, moves with the movements to be registered, to the right and left, in a horizontal plane, in the case of the declination magnet and horizontal-force magnet; and up and down, in a vertical plane, to register the movement of the vertical-force magnet, the cylinder, as before stated, being turned round by clockwork. Consequently, there is traced upon the paper a curve, of which the abscissa, measured in the direction of a line round the cylinder, is proportional to the time, while the ordinate, measured in the direction of the axis of the cylinder, is proportional to the movement of the magnet.

A base line, or a line from which to measure the ordinates, is traced upon the paper by the action of a spot of light proceeding from another gas lamp placed near the cylinder, and passing through a slit fixed to the carrier of the cylinder.

To the horizontal-force magnet there are attached apparati for correction of temperature.

That for the horizontal-force magnet, which is described in the Illustrated Catalogue, page 411 (Second Part), is based upon the following consideration:—

Let (b) be the lower interval between the two divisions of the suspension skein, the equation of equilibrium being—

$$m\,X = \frac{a\,b}{b}\sin\theta;$$

then the arrangement adopted is to make the variation of b, by the effect of temperature, equal to the variation of m, arising from the same cause. This is attempted to be effected by clamping to the magnet a glass rod, the ends of which are inclosed in two zinc tubes, the adjacent ends of which are separated by the width of the clamp. The zinc tubes and glass rod are clamped together at such a distance from the centre of suspension, that the ratio of the difference of linear expansion of the length of glass and zinc intervening between the clamps to the interval (b) may be equal to the temperature coefficient.

The clamps are adjusted in order that, when their position has been approximately determined by calculation, the error of position may be corrected by experiment.

As the expansion of glass and zinc are both taken to be uniform, and are at any rate far beyond the limits of atmospheric change, this method cannot serve to represent the coefficient of (t), and the residual error of the corrected instrument must be experimentally determined.*

The arrangement for the correction of the vertical-force magnet is made by clamping a small thermometer to the magnet, parallel to its axis, and in the same plane as the knife-edges. The middle point between the freezing point of the thermometer and the centre of the ball is placed opposite the centre of the magnet.

Let ν be the weight that at a distance q from the line of suspension would be equivalent to the temperature correction for 1° Fahrenheit, or 32°; w the weight of mercury contained in one degree of the scale of the thermometer; p the distance of the freezing point from the centre of the ball, and $2\,\nu$ the length of one degree of the scale; also let $c\,x + \varepsilon\,x^2$ be the temperature coefficient of the magnet; then if

$$q\,\nu = p\,w, \text{ and } c : \varepsilon :: p : \nu.$$

The statical moment of the mercury displaced from the ball at any temperature x° above 32°, will be equivalent to $c\,x + c\,x^2$, and will represent the temperature correction.

We will now proceed to detail the process of preparing the paper, bringing out and fixing the photographic impression.

The paper used should be of a strong even texture, and prepared with attention, to the exclusion of all foreign substances which might combine injuriously with the chemicals used.

The first preparation of the paper is with—

Isinglass 4 grains.
Distilled water 1 fluid ounce.

The water is boiled, and a portion then poured upon the isinglass, which, when dissolved, is poured into the remaining water, and all is boiled together. To this solution, filtered, is added—

12 grains of bromide of potassium, and
8 grains of iodide of potassium.

One side of the paper is then washed with this solution, and dried quickly before a fire. The paper thus prepared will keep in a dry place for two months.

When the paper is required for use, it must be washed with the following solution, in a darkened room with a yellow light:—

Crystalline nitrate of silver 50 grains.
Distilled water 1 fluid ounce.

* The correction for temperature has hitherto, at nearly every place, except at Greenwich, been applied to magnetical observations, on the supposition that the decrease of magnetical force was proportional to the increase of heat; but this is found to be very far from being the case. The correction for temperature of the horizontal-force magnet at Greenwich is represented by $0\cdot00009050\,(t-32) + 0\cdot000000626\,(t-32)^2$; the second term here becomes very large, when the temperature departs much from 32°, and in Mr. Brooke's arrangement is not taken into account.

To bring out the impression, the paper is washed with the following solution:—

Saturated solution of gallic acid, 1 ounce.
Acetic acid, a few drops.

To fix the impression, first wash the paper well with water, then with the following solution:—

Hyposulphate of soda, 1 drachm.
Distilled water, 5 ounces.

And lastly, wash carefully with water, and leave the paper to soak for a short time. The impression is then fixed, and light may be admitted.

A Council Medal was awarded to Mr. Brooke for this beautiful application of photography to the registration of natural phenomena.

WILTON (No. 402) has exhibited three Fox's dipping needles, furnished with needles of 6½ inches, 4 inches, and 2 inches in length respectively. Those with the longer needles are identical in all particulars to those which have been used successfully on board of ships, both for the observation of dip and relative magnetic intensity.*

PARKES and SON (No. 319) exhibit a number of pocket-compasses.

GREEN (No. 446) has exhibited several magnetic sun-dials, with metal and agate caps, adapted to every degree of latitude. They are mounted in boxes made of various materials. Mr. Green has also exhibited various other sun-dials, some of which are fixed in round mahogany boxes with levels and adjusting screws, and others fitted up for north and south latitudes; also several horizontal sun-dials, and ivory circular thermometers, with compass or magnetic sun-dials attached to them. Mr. Green also exhibits pocket-compasses with metal and agate caps, and others also with floating cards, &c., variously mounted in round boxes with improved hinges. Several compasses are fitted up in variously-constructed boxes of ivory, brass, German silver, &c., together with others in the form of a watch, of various materials, some being made of leather, others in gilt and silver cases.

Mr. Green also has exhibited cone-compasses, and brass gimbal-compasses, intended for use in small boats.

YEATES (332) exhibits a prismatic compass adapted to measure both horizontal and vertical angles, with spiral level attached in such way as to be applicable in both cases.

Electrical Instruments.

The electric instruments are few in number, and there is not one adapted for the purpose of determining the quantity of atmospheric electricity for meteorological purposes. This is a matter to be regretted, as the present state of meteorology greatly needs a simple, inexpensive instrument, adapted for the observation of atmospheric electricity, and one which would be uniform in its action under uniform circumstances.

One exhibitor (WESTMORELAND, No. 444) has, however, the merit of exhibiting a gutta percha electrical machine, which holds out the hope of obtaining electricity of tension on a large scale by the application of steam-power, and thus a motive force, which may serve for the movement of machines, or enable us to accom-

* For description, see Illustrated Catalogue.

plish objects at present quite unforeseen, but which the habitual use of an electric power commensurate with that of lightning may bring into view.

Westmoreland (No. 444) exhibits a gutta percha electric machine. It consists of two rollers of equal diameters, placed one above the other, over which a band of gutta percha, 4 inches in width, is stretched: opposite to the axis of each roller, and on either side, are placed two brushes of bristles. There is a double conductor connected by a curved brass rod hanging over the top of the machine, similar in form to the conductor of plate-glass machines, and also a simple means of tightening or loosening the band, to correct the expansion and contraction of the gutta percha.

It is stated that the electricity given off appears to be of high intensity, and, under favourable states of the weather, nearly as much in quantity as that from an ordinary plate-glass machine. The machine exhibited, when in good order, gave off sparks from about three-quarters of an inch to an inch in length.

This application of gutta percha is quite new in practice,* and indicates the discovery of a new motive power, which promises to be a means of obtaining a supply of electricity of almost unlimited extension: this application of gutta percha opens a new field in electrical research well worth exploring. A Prize Medal was voted to Mr. Westmoreland.

Watkins and Hill (No. 659) exhibit an electrical machine with a glass plate of 3 feet in diameter, furnished with both positive and negative conductors; they also exhibit a dry pile apparatus, furnished with a pair of Zamboni's dry electric piles, with a tangent screw, for the purpose of regulating the distance between the piles, and their position with respect to the suspended gold leaf. This is a beautiful instrument.

They also exhibit a delicate astatic galvanometer, for estimating minute currents of voltaic electricity: the lower needle is surrounded by a coil of wire 230 yards in length, and $\frac{1}{150}$th of an inch in thickness. It is furnished with a rack-work motion, and a microscope for reading. And they exhibit Harris's thermo-electrometer, for estimating small currents either of atmospheric or voltaic electricity, by the heating of a fine metallic wire.

Deleuil (France, No. 160) exhibits an electrical machine for medical purposes, furnished with an arrangement to vary the strength of shocks. It is simple and effective in its operation.

Meinig (No. 437) has exhibited hydro-electric chain batteries, consisting of the metallic combination of various galvanic elements; so arranged as to be very portable.

They are designed to be worn on the body for the purpose of effecting the cure of various chronic diseases, by means of the electric current, which in its passage from one pole to the other passes through that part of the body encircled by the chain.

Thermo-Electricity.

In 1821 Lubeck, of Berlin, found, that if two metals of different kinds be in any way brought into close contact, and heated at the points, a current of

* The electric power of vulcanized caoutchouc is even more powerful than that of gutta percha, and is excited with singular facility.

electricity flowed through the metals, which continued passing in the same direction whilst the heat increased, ceased to flow when the temperature was constant, and flowed in the opposite direction on the cooling of the metals; whence heat was found to be connected with electricity, and like other natural forces, capable of mutual reaction.

Süss (Prussia, No. 482) exhibits a very large thermo-electric battery, with electro-magnet heating apparatus and apparatus for exhibiting chemical reactions. A central ball of heated iron, 2½ inches in diameter, supported on a brass stand, radiates on five thermo-electric combinations, each composed of many elements united by soldering, and are inclosed in brass cylinders about 4 inches in diameter, and connected by copper rods with each other either directly or indirectly, or through a coil passing round a core of soft iron. The circuit thus completed, the magnetic power is developed. Each cylinder has also a chamber for the reception of hot water or hot oil, whose radiation on a similar compound thermo-combination, placed as a diaphragm within the cylinder, develops the thermo-electric current. Honourable Mention was awarded by the Jury.

Hoffmann and Eberhardt (Prussia, No. 88) exhibit an apparatus for showing the action of the earth's magnetism on electric currents, in illustration of the well-known experiments of Ampere, in which helices and frames of copper wire, delicately suspended, when in the act of transmitting the electric current, place themselves in the magnetic meridian.

Application of Electro-Magnetism to the movement of Machines.

The great discovery of Professor Oersted in 1819, to which we have before referred, opened a new field for philosophic inquiry, and especially for the application of an active force, produced without external influence, to the movement of machines. This application, which has since engaged the attention of scientific men, is pretty well represented in the Exhibition: although no great power has as yet been obtained, many important difficulties in its practical application seem to have been overcome, particularly by Mr. Hjorth (Denmark, No. 47), and we cannot help flattering ourselves that the attainment of this mysterious motive force will soon be followed by the making it available for practical purposes.

Joule (No. 440) exhibits an electro-magnet, constructed of a plate of well-annealed wrought iron, 1 inch in thickness, 1 foot in breadth at the centre, and 3 feet at the poles, which are 3 inches in breadth. The iron is rendered magnetic by transmitting the voltaic electricity through a bundle of copper wire (50 yards in length and 1 cwt. in weight) with which it is enveloped; an armature, and a pair of tapered armatures, are also exhibited for the purpose of concentrating the magnetic force when the electro-magnet is excited by a feeble voltaic current, and of directing the magnetic action to any required object. The superiority of this over other electro-magnets consists in the attainment of much greater magnetic force from a given voltaic battery, than has hitherto been attained. Its use is to magnetise bars of steel and compass-needles, to which it instantaneously imparts a larger and more regular dose of magnetism than can be given by the usual means. It may also be employed to exhibit the phenomena of magnetism and diamagnetism.

Mr. Joule also exhibits a surface electro-magnet, consisting of a thick piece of wrought iron enveloped by a bundle of copper wire. The exhibitor observes, that a battery of moderate power produces such a powerful attraction between the above electro-magnet and its armature, that a weight of more than one ton is necessary to be applied in order to draw them asunder. This illustrates the extraordinary attractive power of iron when fully magnetised.

HARRISON (No. 420) exhibits an electro-magnetic engine which acts on the principle of the induced magnetic power of a compound coil of insulated wire, conveying the current to a series of plates of soft iron, and attracting them within a suitable aperture.

As there is only one body of wire in connection with each coil, the retarding influence of the electro-magnets acting upon each other, after the current from the battery is cut off, is avoided, and by this arrangement the effects of the secondary currents are much reduced. The coils are made of short lengths of wire, and the whole are enclosed in metallic cylinders: it is presumed that a considerable saving in the consumption of the battery materials is effected. The advantages, Mr. Harrison says, are :—

1st. An almost unlimited power and length of stroke.

2nd. The greatest possible amount of power from the battery, by reducing the influence of the secondary current to a minimum.

3rd. Avoiding the retarding influence caused by the retention of magnetism in the ordinary method of application by magnets; and from the body of iron acted upon by the coils exposing a large surface, an instantaneous and powerful induction of magnetism ensues, and thus the highest speed is obtained.

4th. By the employment of a compound conducting material, a strong current of electricity is transmitted, and a much greater magnetic effect within the same space is obtained.

5th. The larger the iron plates, and the greater the power of the battery, the greater is the economy of this engine.

KNIGHT and SONS (No. 453) exhibit an electro-magnetic engine. This is probably the simplest form by which an electric current can be made to work by its action on permanent magnets, though not the most effective. Four coil-magnets are fixed rectangularly on an axis, and revolve within a circle formed of four fixed magnetised quadrants. The contacts are made and broken by rubbing springs on an axis (so it appeared on examination); the nicety of construction consisting in the adjustment of the moments of union and disruption, so as to obtain an effective difference of action always in the direction between the two opposite poles of the permanent magnet.

Knight also exhibits another electrical machine, in which a bar is alternately pushed and pulled, and so working on a crank and turning a fly-wheel. In all these machines the mechanism itself provides for the necessary alternate making and breaking of the circuits. It is probable that little power is obtained, for the greatest care appears to have been taken to destroy friction, by making the fly-axis revolve on friction-rollers.

WATKINS and HILL (No. 659) have exhibited an electro-magnetic engine. Two horse-shoe electro-magnets are alternately excited by two electric currents, and each as it becomes a magnet attracts one of the arms of a rectangularly-bent iron bar, which is thus kept in a state of oscillation round a pivot from one magnet to the other. The ends of the bar carry rods working on joints, which are connected with cranks rectangularly placed on an axis. Thus the dead point of one crank coincides with the quiescent state of its own magnet and with the active state of the other, and the axis is maintained in rotation with its fly-wheel. The magnet, bars, and crank are so arranged along the axis as to give room for the cranks, of which there are two, though, in fact, there might be any number of magnets and cranks working simultaneously. The alternation of the circuit is kept up by a mechanism worked by the machine itself.

ALLEN (No. 413) exhibits an electro-magnetic railway-train alarm: it consists of a copper chain, intended to be placed over every carriage, the connection between each being established by the guard-chains; on the circuit being completed, the ordinary steam-whistle discharges the steam. The arrangements are as simple as well can be.

CRESSWELL (No. 417) exhibits an electro-magnetic engine for the production of motion: it consists of two pair of electro-magnets, between which a keeper vibrates and communicates motion to a wheel and crank.

FROMENT (France, No. 1609) exhibits an electro-magnet acting alternately, by elevating a lever, which communicates motion to a crank. He also exhibits a circular arrangement of coils, two of which are in action successively.

BRETON (France, No. 113) exhibits an electro-medical apparatus with a double current; but as this instrument is intended for medical purposes, and not as a motive power, it scarcely falls within the province of this Jury.

HJORTH (Denmark, No. 47) has exhibited an electro-magnetic engine. It consists of two sets of hollow horse-shoe electro-magnets, conical inside, with a corresponding number of solid electro-magnets, which, by mutually attracting each other, make a double stroke of 4 inches in length. The power has been found, by means of a spring-balance, to be about 30 lbs. at the commencement of the stroke, when the distance of the respective poles is about half an inch, decreasing slightly by degrees as the piston enters the hollow electro-magnet. The current is broken by the end of each stroke, and the destroying effect of the spark prevented by moistening the surface of communication with diluted sulphuric acid; no repelling power is applied.

Mr. Hjorth also exhibits a diagram and plan for an improved arrangement, consisting of only one hollow electro-magnet, the respective poles of which are divided into three or more square rings, which are somewhat conical inside, and are connected outside with the armatures (?) of the magnet, which form the connection between the respective poles. From the upper and lower part of the arrangement extend withinside four iron plates with ribs, which in the centre are connected with corresponding diamagnetic plates and ribs. These plates are applied for guiding the motion of the piston, and serve at the same time as a means by which metallic contact may during each stroke be established and broken between the piston and any one of the respective plates. For this purpose, four pairs of rollers are placed withinside the piston or hollow shafts, which are arranged on the four-way-cock principle, with a ring, inlaid with diamagnetic metal between the rings and shafts, that the magnetic bearings may be brought into contact either with the similar or diamagnetic parts of the same rings.

The required motion of these rings is produced by small cranks inside the piston, joined to the connecting-rod in such manner that each pair of cranks moves in opposite directions.

Whilst the engine makes a down stroke, magnetic contact is established between the north pole and piston: the polarity thus acquired causes it to attract the south pole. When the down stroke is performed, the magnetic contact between the north pole and the piston is broken by turning the upper pair of cranks in one direction, whilst similar contact is established between the south pole and piston by moving the lower pair of cranks in the opposite direction. A reciprocal motion being obtained in the above manner, the electric current passes continuously in one direction round the piston and each of the poles, the motion of the piston being reversed by simply breaking and establishing magnetic contact. On the piston passing out of the one pole it enters the other, and induces thereby, according to the law of the secondary currents, two currents in opposite directions, and thus both are neutralized. The advantages assumed are:—

1st. The obtaining a stroke of any length with one hollow electro-magnet, the piston being a moveable extension of either of the poles, attracted by a succession of polarities, the acting surfaces of which extend to the whole circumference.

2nd. The arranging the piston in such manner that it may be extended to any size, without its being heavier than a piston in a low-power steam-engine of the same size, the power being expressed in pounds per square inch.

3rd. A prevention of the destroying effect of the electric spark.

4th. A neutralization of the secondary currents and a prevention of their reaction.

The following table, as obtained by Mr. Hjorth, shows the attractive power obtained with a horizontal electro-magnetic engine of 16 inches stroke, the poles of the moveable magnet being separated 6 inches, or, in other words, the piston being 6 inches square:—

Distance of the respective poles. (Inches.)	The attractive force was (lbs.)	And the angle of magnetic force was (° ′)
5	72	75·58
4	80	72·39
3	98	67·22
1½	140	50·12
1	160	42 34

A Prize Medal was awarded to Mr. Hjorth.

Electric Telegraphs.

As might have been expected, there are exhibited voltaic batteries; galvanometers; electro-magnets; telegraph wires; wires for submarine purposes; printing telegraphs: in fact the Exhibition is rich with a large number of very ingenious contrivances, applicable to every stage of electric telegraphic communication.

The Electric Telegraph Company, which was established in the year 1846, have evidently used much diligence in possessing themselves of numerous patents, commencing with Cooke and Wheatstone's five-needle telegraph, patented in 1837, up to the present time. In the fine collection they exhibit are some of the most valuable inventions, in point of real practical utility, that have yet occurred;

but they include also many forms of telegraph which, judging from their not being made use of, have been, it is presumed, found to be of little practical value.

It would seem that the needle telegraph, giving conventional signals, has obtained a firm standing in this country; and with the recent improvements in the galvanometer, it has certainly attained a high degree of perfection.

The form of the needle in most general use is that of a small rhomboid, into which much magnetism can be imparted, and which vibrates with great steadiness and rapidity. It, however, has the disadvantage of parting with its magnetism much more readily than longer needles, and requires to be remagnetised more frequently.

When we reflect how very few years have elapsed since all that was known upon this subject (now the science of the age) was confined to a few scientific men, and regard its subsequent rapid progress, and probable great extension,* it cannot fail to be both interesting and instructive to trace briefly its progress, and to examine somewhat in detail the essentials of electric telegraphs, with the view of seeing how far such are attained in those exhibited. It is not the purpose of this report to trace the history of inventions, but one of its principal objects is to give merit wherever it is due; and it is hoped that the following attempt to classify telegraphs, being the first which has been made, is well within its province. In drawing it up we have to acknowledge our very great obligations to Charles V. Walker, Esq., the Telegraph Engineer to the South-Eastern Railway Company, for the kind assistance which he has freely given.

The idea of utilizing the electric form of force, so as to have the means of rapid intercommunication between places far apart, is coeval with the discovery of the exceeding velocity with which this force travels through good conductors; and hence, as far back as 1782, we have a M. Lesage proposing to deflect twenty-four different leaves of gold, at the end of twenty-four distinct wires; and in 1787 we have a Mr. Lomond passing signals from room to room, by means of a Leyden jar and an electroscope—experiments useful enough as scientific illustrations, or as philosophical toys, but of no practical value. Indeed, so long as we were in possession of no other form of electric force than that which is obtained in a state of high tension from the joint friction of suitable bodies, there were no hopes, even had man been ready to take up such an invention, of an electric telegraph, properly so called. We find Reizen and Salva at the close of the last century, and Ronalds at the commencement of the present, doing their best to render this wild and wayward form of electric force subservient to their purposes; and the latter effectually controlling it within certain limits, and making a telegraph that did some actual work. It was not, however, until Galvani's discoveries had opened out a new field of electric research, which was so successfully trodden by Volta, when it was found that certain relations existed between heterogeneous bodies, attended always by the production of electric force in a new and much more manageable form;—it was not until this discovery of voltaic electricity that the idea of an electric telegraph became developed with any distinctness. We then perceive

* At the time of our writing, the wires are being laid from Dover to Calais, thus connecting the Continent with our system of telegraphic communication; and arrangements are being made to connect the Observatories of Greenwich and Paris.

an advance; and although the applications that first occurred were sufficiently clumsy and impracticable, as compared with the knowledge we now possess, there was enough in Soemmering's decomposing points, in Coxe's decompositions, in Vorsselman de Heer's electric shocks, and in other original ideas, to prove that the prospect of ultimate success was still entertained.

But when Oersted had discovered that this new form of force, voltaic electricity, had a constant relation to magnetism, and that its presence caused the compass-needle to deflect according to unvaried laws—and when M. Arago had discovered that the same force would endow an inert mass of iron with all the wonderful properties of a magnet—we became possessed of powers, which only required rightly to be handled and controlled, for the solution of the problem; and when, further, Faraday had discovered that the mere motion of conducting bodies in the neighbourhood, or within the sphere of magnetic influence, gave rise to electric force; and Pixii first, and Saxton ultimately and effectively had worked out this discovery, and had produced the magneto-electric machine, there was a choice of means for producing the actuating force, and we could use at our pleasure this or that means of generating, what is popularly termed the electric current. A third source from whence might be obtained the means of actuating the signalling apparatus, was found in Faraday's further discoveries of the induction of currents in one set of conductors, by original currents passing near them in other sets of conductors. It may be supposed that during this last stage in the history of electric telegraphs, extending as it does to this very hour, many unsuccessful attempts were made, and many discoveries were introduced to the public eye, only to be abandoned as futile, and as wanting many of the essentials to real success;—the name of these is almost legion.

The Exhibition contains many inventions which are most valuable. Perhaps it would be well to consider here the essential or fundamental points of an electric telegraph; they are three in number and are as follows:—

I. *The Generation of the Force.*
II. *The Insulation of the Force.*
III. *The Utilization of the Force.*

We will proceed to speak of them separately.

I. *The Generation of the Force.*—In the majority of electric telegraphs in actual use, batteries composed of heterogeneous metals, moistened by a liquid or liquids, are employed for the generation of force. We find that Grove's combination of zinc and platinum, excited respectively with dilute sulphuric acid and nitric acid; Daniell's, of zinc and copper with dilute sulphuric acid, and sulphate of copper; Smee's, of zinc and platinized silver, with dilute sulphuric acid only; Cooke's original telegraph battery of zinc and copper with sand, and dilute sulphuric acid; Walker's graphite battery, in which the corrosion from gas retorts is substituted for the copper of Cooke's; and other forms, have been used by different inventors. But where a telegraph really requires the more expensive and complex form of battery first described, there is a *primâ facie* case against it; for in the maintenance of a large establishment, the cost of such battery power would be proportionably great, and unless compensated by some very great advantages on the part of the telegraph would be regarded in no very favourable light. Siemen's telegraph (Zollverein 310A), for instance, is most ingenious and is well constructed; but whether it possesses advantages over other known plans, that will compensate for its requiring to be worked with Daniell's battery, remains to be proved. Again, though as a reading telegraph it should not hold this rank, its printing powers, as compared with other printing telegraphs, might be greatly in its favour.

The ordinary acid battery has been almost invariably used in England. It is the least costly in construction, and is maintained at the least expense: it remains active for a considerable time, but suffers ultimately more during its resting than during its working periods, on account of the combinations that occur between the sulphuric acid and the copper, with the subsequent decompositions. With graphite plates this defect is remedied. The Prussian telegraph has the peculiar advantage that the batteries, both at the sending and receiving stations, are simultaneously in the circuit; and for long distances it avails itself of battery power at intermediate stations. The American telegraphs, in like manner, throw local batteries into circuit to do the actual work. This peculiarity occurs in some of the English patents, but does not seem to have been introduced into actual practice.

Perhaps the most curious proposition for the conversion of battery power into language is that of M. Botto, whose signals depend on the number of pairs of battery plates employed to deflect the distant needle, and are interpreted at the receiving station by turning on pair after pair of plates in the reverse direction until the needle comes back to zero, when the number of cells required to do this gives the letter or signal. The idea is original; but in order to carry it out the batteries must be precisely of equal power, and no portion of the force must be lost in transit.

The earth itself has been made to furnish a supply of electric force; in other words, a single pair of zinc and copper plates have been buried sufficiently below the surface to be in the wet subsoil, when the earth, saturated with water, represents the sand saturated with acid water, of an ordinary battery cell; by this means a current of low intensity is obtained, even when the plates are some miles apart. It was thought by some that this feeble current might be made available for telegraphic purposes, by laying one metal at one station and the other metal at another, and very exaggerated propositions were put forth. Steinheil rejected this mode of obtaining the current, which is only available, and that very indifferently, at the place where both plates are buried.

The means of turning on the electric force, or setting the current in motion, are as various as are the different inventions: in one case, consecutive depressions of a single stud are made, and a current is sent in one direction only; in another, handles or levers are moved in either direction, and two directions of current ensue; in another the current is turned on in a constant direction, and the action of the instrument breaks and renews the circuit; in another the whole force is sent along one wire, or is divided between two, and is directed this way and that as the case may be.

The magneto-electric machine is a constant fountain of force: it does not vary in power, as do batteries, nor ultimately become exhausted, but remains for an unlimited time capable of generating the induced electric current. It consists essentially of a set of powerful permanent magnets, and a coil or coils of copper wire wound upon iron cores; the ends of the copper wire being led off to adjustments proper for distributing the force in the right direction. The current is obtained by briskly moving the coils in presence of the magnet, making, in fact, the conducting wires to move among the lines of magnetic force. Where single currents are required, one motion of a lever on the other arm of which the coils are fixed, gives one instantaneous current. Where, as in Wheatstone's instrument, a number of consecutive currents are required in rapid succession, the coils are mounted on an axis which can be made readily to rotate, and to rest at any required point. Where, as in Henley's instrument, the force is required along one or other, or both of two wires, coils are mounted on levers near each end of bar magnets. Steinheil, Dujardin, and Hatcher are among those who have employed the currents from this source. When the current of high tension, induced from an ordinary current of low tension, is wanted, a cell or two of the more constant form of battery is employed to pass a current along a coil of stout wire surrounded by a long coil of thin wire, which latter is permanently in the telegraph circuit, and out of which is generated the active force.

II. *The Insulation of the Force.*—This is unquestionably the most difficult part of electro-telegraphy. It has engaged the attention of practical men from the outset. It is in vain that an abundant supply of electricity is obtained—it is in vain that the best measures are contrived for turning on this supply, and vain is the expenditure of thought, and contrivances for converting this electricity into a representation of our ideas—if the means are defective for conveying it in its integrity to its destination. Electricity of high tension, such as was employed for the early illustrations of signalling, might have been sufficiently well passed by Lomond from room to room, if his wires were carefully suspended, and the atmosphere tolerably dry; but when Ronalds proposed to pass the same agent along a distance of only 175 yards, he was compelled to surround his wires by thick glass tubes, well coated with wax at the joints, and placed underground in wooden troughs lined within and without with pitch. Frictional electricity, as is well known, requires perfect insulation to prevent it passing off in the form of the electric spark. Weber, in 1833, had found the voltaic current to be retained in wire of about a mile and a half in length, which was merely suspended from the steeples and house-tops of Göttingen. Steinheil, in 1837, erected and worked his telegraph at Munich, through a distance of about six miles, with no other insulation than a piece of felt placed between the wire and the support; but he found the insulation imperfect, and the more so in wet weather; and saw clearly that the force would have been altogether dissipated, had the circuit been longer.

The suspended wires are at the present time occasionally insulated from their supports by glass, but more commonly, as in England, by hard well-glazed stoneware. Much ingenuity has been exercised in the form to be given to the insulators, of which there are many in the Exhibition. The barrel-shape, pierced longitudinally, universally prevailed here until long circuits called for some more perfect form; and now in the bell or mushroom, the bold, open-mouthed cone, or other analogous forms, we can discover that the actuating idea has been to keep the points of contact dry, and to let the interval between the wire and the pole be a maximum. Walker (No. 430) has gone a step further, and has placed a closed roof over his insulators. Cases occurred in which it was found convenient, even in the early days of telegraph, to lay the wire on or near the ground, and eventually under the public streets, when it was covered with cotton saturated with tar and pitch, and protected by leaden pipes. This was found to be very inefficient, nor did much better success attend the use of caoutchouc, which was not only expensive, but neither manageable nor durable under the conditions to which it was subjected. By a most happy coincidence, gutta percha appeared in the market at the time, when resins and varnishes, and the known gums had been tried and found wanting. It was appropriated by Siemens in Prussia, who employs buried wire very largely, and by Walker in England, who used it at first between Dover and Folkestone, and now extensively in tunnels and under water, and who demonstrated its value for submarine purposes by sending signals to London with two miles of gutta-percha wire (a piece of which wire is exhibited) in circuit, in the sea at Folkestone, in January, 1849. The street wires and tunnel wires, as well as those submerged in England, Belgium, America, and elsewhere, are now perfectly insulated by a coating of this valuable material. It is applied warm, either by powerfully pressing it upon the wire, or by causing it to follow the wire through a hole of the given size. In the streets the wires are sunken, and protected by being inclosed in iron pipes, which proves to be very necessary, for in Prussia where they are buried without protection, they suffer so frequently from the attacks of vermin, that it is in contemplation to suspend them as we do.

Under rivers or harbours they are protected by pipes, or are secured in a mass of timber, or otherwise. In all the tunnels on the South-Eastern line, Mr. Walker has laid them in grooved boards, which method has been since followed by the Telegraph Company, and is also adopted by the Belgian Government on their lines. It is unquestionably the simplest and safest of all methods.

The protection required for submarine wires is very great. The wire, by means of which a telegraph communication was obtained for a few hours between the coasts of England and France, was not calculated, neither was it expected to remain perfect for many days. It was clearly not laid down with the intention of remaining permanently, but for some special object. It was a copper wire, coated in the ordinary way but thickly with gutta percha, and where it reached the shore, protected by a leaden pipe.

McNair (No. 429) has exhibited some excellent specimens of his process of covering gutta-percha wire first with cotton and then with an outer coat of gutta percha, and finally with lead, in the application of which latter the cotton becomes impregnated with gutta percha from the outer coating.

Wrought-iron chain-pipes, with swivel joints, have been constructed by Wishaw (No. 419), and are exhibited as means of protecting submarine wires. Brett shows a sort of vertebrated hollow iron chain of considerable strength, which is proposed to be built about the wire. But there appear practical difficulties in the application of these plans. We see some insulated wire, protected by a strong network of wire woven over it, which imparts great strength and elasticity, and will often be found useful. The wires prepared for establishing communication between England and France, are coated first with gutta percha, and then twisted together, being four in number, thickly covered with rope-yarn saturated with tallow and pitch, and finally protected with galvanized iron wire of the thickness of a quarter of an inch.

A plan worthy of commendation for its simplicity, and for combining the leading essentials of a submarine wire, has recently appeared. A chain cable, of sufficient strength to resist any strain to which it might be exposed, is galvanized; gutta-percha wire is covered with tape, or a similar material, saturated with creosote and other matters offensive to animalculæ; outside this is another coating of gutta percha, and around the whole galvanized iron wire is wound, like the wire of a harp string. One or more wires are inclosed in the outer coating of gutta percha, before applying the galvanized wire as may be required. The chain is arranged regularly, that is with the links alternately vertical and horizontal; and in the four corners or angles presented is laid one of the wires prepared as above, which is retained *in situ* by simple slips of galvanized iron, from which it can be readily released. The full strength of the chain is thus increased by the addition of the wires, and the combination is very elastic and manageable.

Insulation is not a little dependent on the state of the circuit, that is to say, on the relative amount of *resistance*, opposed to the passage of the force. In short distances defective insulation is not much felt, for the resistance offered by a few miles of wire, which is a very good conductor, is far less than that presented by the films of water or other bad conducting material near the insulators: the relations of these resistances vary with the length of the wire, and also greatly vary if the resistance of the wire is increased by badly-made joints. In early days the lengths of wire were joined by mere contact, and the pressure of a nut or bolt; and the winders by which the wire was tightened formed part of the circuit. This plan was found by no means to satisfy the conditions essential to long circuits; and now the joints are made with scrupulous care, and the lengths of wire are soldered together from end to end, the winders not being allowed to enter the circuit.

Steinheil had discovered, in 1837, that it was not necessary to lead a wire from each pole of the battery to the respective sides of the telegraph apparatus at the distant station, as would be done in all experiments on a small scale, but that the conducting powers of the earth could be advantageously substituted for one of the wires. The saving of one out of every two wires, important though it is, is not the only advantage derived from this discovery. The earth is found so far to surpass the wires themselves in conducting power, that it adds nothing to the resistance; so that equal effects may be produced at double the distance with the same initiative force. The resistance therefore for any given distance is one-half, and the tendency towards defective insulation is reduced. The earth acts as the return wire, to any given number of distinct wires, without in the least affecting the regularity of the action of any of them.

III. *The Utilization of the Electric Force.*—Almost every effect by which the presence of electric force is made manifest has been in turn enlisted for the purpose of transmitting our ideas to a distance—not excepting even the heating effects of electricity, which have been employed by Horn to ignite wire and singe signals on paper.

1. The spark was employed by Reizen, who pasted strips of tinfoil on glass, and cut out the letters by dividing the strips, which intervals were illuminated by the spark. Salva used the spark, but how converted into language was not known.

2. Recession of similarly-electrized bodies occurred to Lesage, who proposed twenty-four wires with a pair of gold leaves at the end of each; one or other of the pairs was to diverge by an electric charge. Triboaillet proposed something similar, with only one wire and conventional signals. Lomond used a common electrical machine and a pair of pith balls and conventional signals. Ronalds employed pith balls, and two well-regulated time-pieces, which carried round similar discs of signals, each presenting the same signal at a fixed point at the same time. He deflected his pith balls and discharged the electricity, allowing them to fall when the right signal arrived at the given point.

3. The *physiological effects* of electricity, in other words the electric shock, was proposed by Vorsselman de Heer, and actually tried in 1839. He had ten wires, and ten keys or studs on which the fingers of the hands were to be placed; and the shocks felt in the various fingers constituted the signals. Instead of an alarum to call attention, the clerk had merely to connect himself up in the telegraph circuit, when he might safely rely on being feelingly reminded when his attention was required. O'Shaughnessy proposed giving shocks from the induced current, one shock and a group of shocks being the distinctive marks; and each station being provided with time-keepers, having a disc of signals, a shock to be given when the index pointed to the letter intended.

IV. The *decomposing powers* of electricity suggested themselves to Soemmering. Some twenty or more wires terminated in gold points, within a vessel of acid water, and according as the circuit was made by one or other of the wires, a small stream of gas ascended from its terminating point, and hence the alphabet. He also contrived that an inverted cone should collect the gas, and would then float and cause a little ball to fall on a detent to liberate a clock mechanism and a bell. Coxe proposed the decomposition of water, but gave no plan. Davy impregnated cotton with hydriodate of potassa and chloride of calcium, and having marked it off in chequers, secured it on a cylinder that rotated by a clock movement. The current has to be directed through the cotton, and to produce a spot: the chequer on which this spot fell determined the signal. The clockwork was released by an electro-magnet, actuated by a current in other wires. Bain's printing telegraph depends on the same principle, applied however to the decomposition of more sensitive bodies, and reduced to actual practice. He acts upon a mixture of sulphuric acid and prussiate of potash, with which he moistens paper bands. The paper is interposed in the circuit, and receives a mark wherever the current passes and decomposes the solution. The alphabet consists of a combination of short and long marks, produced respectively by instantaneous currents, and by currents of short duration. These currents are sometimes sent by hand, by mere making contact; at other times short and long holes are punched in a dry paper band, and this is drawn by clockwork between the metal point and cylinder, which closes the circuit, and thus the current is cut off, when the sound part of the paper intervenes, and passes when the presence of a hole allows the point to touch the cylinder, and complete the circuit—the moist paper receiving the spots is made to move on at a like rate. Bakewell places his solution in like manner in a paper band; but he writes his messages with varnish upon tinfoil, and places this between the point and cylinder, and causes the latter to revolve, and hence the current is intercepted wherever the varnish intervenes;

the moistened paper revolves at a like rate, and both progress axially, so that a fac-simile occurs of what had been written.

V. The *galvanometer* has been most successfully pressed into telegraph service, and forms the essential part of the needle telegraphs which have obtained so marked a reputation in England.

Steinheil used one galvanometer coil containing two needles, which carried ink cups, and made dots as they were deflected. Alexander had thirty wires and galvanometers, the needles of which carried screens and disclosed letters on their being deflected. Schilling, according to one account, used thirty-six wires and galvanometers, and, according to another account, only one; and he had a plan for checking the oscillations of the needle. Davy showed, in 1836, what was apparently a needle telegraph, somewhat similar to Alexander's. Gauss and Weber had a single-needle telegraph, the deflections to be observed with a spy-glass. Fechner suggested twenty-four galvanometers and their respective wires. Botto's plan of one galvanometer, whose deflections were to be neutralized by an adverse current, has been already named. Mason suggested a single galvanometer. Galton has published a description of a very complex apparatus, the electric parts of which are three galvanometers, whose office is merely to present needles as mechanical obstacles in certain spots among a train of machinery. Cooke and Wheatstone at first used five needles on a lozenge-shaped dial, two of which were always used for a signal; and the letter was found where the points produced met. The needle instrument, now in common use, and in which one or more deflections of either or both needles, in one or other direction, gives all the combinations necessary for conducting rapid correspondence. The details of these instruments have been much improved, and there is little wanting to make them perfect. There is also a single-needle instrument, which gives all necessary signals, but not so rapidly. The success of the needle telegraph has led to many modifications of the galvanometer. Brett and Little coiled the wire on a circular bobbin, and make a crescent-shaped needle, the poles of which are properly presented to the coil; instead of reading from the prime motion of the needle itself they read from indices, which are moved by a tap from the needle. Highton's galvanometer needle is horse-shoe shaped, and the coil also circular and duly adjusted to the needle. He reads from an index carried on the same axis with the needle. He has also three needles, each carrying a screen, transpierced in such sort that by a combination of motions twenty-six different letters can be exhibited to the eye. Little has suspended an ordinary needle to the pole of the magnet, and withinside a tube of alcohol. The galvanometer coils are flat bobbins.

The *electro-magnet* has been used by Bain, Bakewell, Barlow, Breguet, Brett, Cooke, Davy, Dering, Dujardin, Garnier, Hatcher, Henley, Highton, House, Lodefink, Morse, Nott and Gamble, Palmieri, Siemens, Smith, Vail, Wheatstone, Wishaw, and others. In the hands of some of these inventors it has been made to give direct signals; for instance, in *Henley's instrument* the armature carries the index-needle, and the combination of the deflections of two needles gives the alphabet. In Morse's the armature carries a point which impresses permanent marks on paper; it is also connected with wheel-work for moving the paper onward. In Dering's the magnetized armature carries the index-needle. In Dujardin's the armature carries a point that dips in ink and makes dots. Siemens' prints by the direct blow of a hammer carried by the armature, although his type is brought in by a secondary action. In the hands of others it communicates motion to the index, as in Breguet's semaphore instrument, where the armature acts upon scape-wheels, and gives to the indices the eight positions of the ordinary semaphore. In Nott and Gamble's, the armatures carry claws that draw a wheel round, and with it the index, till it points to the given letter. In Siemens', the armature acts in a similar manner. We also find a third class of instruments in which the motion of the armature releases a detent, and liberates a clock-train, the motion of which produces the signals. Cooke and Wheatstone's alarum is sounded in this way, the hammer in some cases representing the pendulum bob, and in others being carried on the produced radius of one of the wheels. Brett prints by the successive action of a detent liberating clock-work. It would be no easy task to follow the several inventors through the essential details of their apparatus; nor would it be very practicable to prepare a complete list of all that has been either conceived, contrived, or constructed, together with all that has been tried, and proved successful or otherwise in this wide field of research It may well be supposed that many of the plans to which we have referred, have existed only in imagination—that many are absolutely useless—that many others are too complex for actual service—that some perform badly and with uncertainty that which others accomplish rapidly and successfully.

The French Government required signals to resemble those of the old semaphores, and they have extensive codes. We have in England preferred conventional signals, thinking it better to train young men to read a new alphabet than to have an index going through the comparatively slow operation of pointing to every letter. In Prussia the latter plan is preferred. There has been, also, a choice between reading and printing instruments: in America the latter have prevailed; in England the former. But whatever be the actual sign by which we obtain possession of the ideas transmitted to us, it would seem that the instruments that have obtained a standing, are, almost without exception, those whose action is direct, and are not the result of any extraneous mechanism.

We will now proceed to a careful description of the several telegraphs.

The ELECTRIC TELEGRAPH COMPANY exhibit many telegraphs.

I. Patent 1846, a rhomboidal needle. The galvanometer coil is in two halves, mounted on arms, which are made to open for the reception of the needle, and to close again. On the same axis is mounted the index-needle that is presented to the eye on the face of the telegraph, and which oscillates between ivory studs. The studs are now made moveable, as first proposed by Charles V. Walker, Esq., Telegraph Engineer to the South-Eastern Railway Company, for the needles to work between, so as to keep the neutral position, by adjustment, half-way between them during periods of magnetic disturbance.

II. WHEATSTONE.—The instrument marked "Magnetic-electric Induction Machine," consists of a strong horse-shoe magnet, of eight plates, and 10 inches from either pole to the centre, fixed on a board; over it is placed a handle, which raises and depresses two coils with soft iron core and armature. On breaking contact, by depressing the handle, a current of momentary duration passes out from one coil along the wire to the other *in one direction*. This gives a single impulse only, and always one way; and is used to excite an electro-magnet, and ring a bell.

III. Hatcher's magneto-electric induction machine, to send currents, *ad libitum*, in either direction. This is effected by the same application of coils to a horse-shoe magnet and breaking contact; but there are two handles, and according as one or other is used to break the contact, cross communication takes place. "Hatcher's Current Director" affords a mode of making and breaking contact by cross communication, as an appendix to any telegraph. In this machine the horse-shoe is 12 inches in length, and consists of eight plates.

IV. Wheatstone's patent rotating induction machine, for working the disc telegraph (1841). A dial wheel with spokes and letters. Each letter as it is wanted is brought to a given point. The wheels work a pinion, which causes a pair of coils and armature to revolve over the poles of a great horse-shoe magnet. Every letter brought past the given point makes half a revolution of the coils and breaks, and renews the circuit opposite ways. The currents thus established and sent off to a distance, pass through coils and actuate local electro-magnets, which alternately attract to and fro an iron plate, and thus alternately release and lock a detent. A clock, driven by a spring or weight, being thus allowed to act at intervals, drives round a dial-hand, click by click, at the other station, and thus imitates the motion of the original dial-wheels. This clock, however, requires to be wound up, and it does not seem to provide for any notice being given when it is down.

V. Barlow's patent, 1848. A printing telegraph, consisting of a circle of letters brought round in succession till the letter wanted comes to a given place; contact is broken as each letter passes, and the current is reversed; the currents so established act (at the other station) as four-coil magnets, &c., between which a soft iron bar is thereby caused to oscillate, and to lock and unlock an escapement, and cause a wheel to imitate the motion of the letter circle. This wheel brings round type punches, and on coming to rest a hammer strikes the punch (worked by a coil-magnet), and impresses a paper ribbon, which is drawn uniformly along by clockwork.

VI. Nott and Gamble's telegraph presents two double alphabets; the one direct, the other inverse, and the digits are many times repeated on a circular dial, having an index, which moves with a step-by-step motion, and is brought to rest at the letter required. The force is derived from the voltaic battery; and current after current is set in action by the successive depression of an ivory key by the finger; it is made available by means of two U-shaped electro-magnets, acting simultaneously and in the right direction upon two levers, furnished with clicks, which work in a scape-wheel that carries the index, and propel it, notch by notch, as each contact is made.

VII. Hatcher's induced current machine, patent 1847; to produce currents in either direction by one motion of a handle.

Two make and break circuit arcs of brass and ivory-pieces, alternating with rubbing-springs, so arranged that when the springs on the right arc connect brass and brass, that on the left shall connect ivory and ivory, and *vice versâ*. In either state, a depression of the handle breaks contact of coils with magnets, and throws a shock along the wires.

VIII. COOKE'S patent, 1845. A portable telegraph, for the guard on a railway to *receive* messages in case of an accident, by making a contact with the regular wires along the line.

IX. BRETT and LITTLE'S patent. A conventional alphabet by needle oscillations, in which the handle at the first station, by working to and fro, establishes alternate cross communications, and thus directs the current alternately one way or other. There are two needles, but each needle oscillates in only one direction.

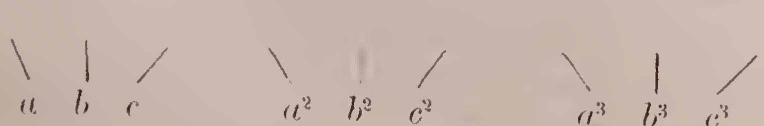
X. WHEATSTONE and COOKE'S patent, 1840. In this arrangement the rapid alternation of circuits is effected by the dial-wheel turning a pinion, half of ivory and half of brass. The motion of the dial-wheel is imitated at the second station by an escapement-wheel, driven by the oscillation of a pair of detents worked by a four-coil local magnet apparatus alternately urging a piece of soft iron to and fro. It is an imitation telegraph, and reads the actual letters.

XI. HATCHER, 1847; electro-magnet printing telegraph. The usual reciprocating action between coil-magnets, instead of carrying round a wheel, makes a series of dots on paper constituting a conventional alphabet.

XII. BAIN'S patent, 1846; chemical printing telegraph. Signals are given by marks arranged in one line of different lengths and intervals by the pressure (on prussio-muriated paper) of a link of iron wire, which deposits prussian-blue, the paper being adjusted by clockwork.

A Prize Medal was awarded to the Electric Telegraph Company for the exhibition of this fine series of telegraphs.

The BRITISH ELECTRIC TELEGRAPH COMPANY (No. 432) exhibit HIGHTON'S patent, dated 1848. The principle is economy of wire by encircling the poles of a horse-shoe, rather than going round a straight magnet. The power gained is stated to be as 7 to 1. An improvement is also claimed in the mode of throwing two lines into connection by a single spring and cross bars, so as to halve the risk of a spring breaking. Thirdly, carrying a coil all round a horse-shoe, and thus causing each part of the magnet to act on each part of the coil; but this is in opposition to the first principle, so far as a saving of half the wire is concerned. Fourthly, application of the principle of the arrangement of the letters on the rim of a dial-plate, not according to alphabetical order, but according to frequency of occurrence in writing: but arrangements of this kind have been in use in printing offices, on the principle of the more frequent letters being placed the most within reach. Fifthly, a ready mode of bringing the needle on the alphabetical-dial to zero, by touching a key. The step-by-step current which works the needle round is thus thrown out of gear, and its power thrown on another magnet, creating a force which lifts the detents of the escapement, and lets it pass round to the stop in the same direction. Sixthly, is exhibited a very ingenious piece of mechanism for locking the printing-wheel, so that it cannot by any possibility run on two letters for one motion of the alphabetical needle. Seventhly, since $3^3 - 1 = 26$, the number of letters in the alphabet, and since $3^3 - 1$ is also the number of electric combinations of three oscillating needles; thus—



of which b, b^2, b^3 is an inactive combination arising from a quiescent position of all the needles; a conventional alphabet may be constructed by a simultaneous use of any three of the combinations, except b, b^2, b^3; thus, \\\ may indicate A; \\/ may indicate B; and so on.

This principle is worked out by a system of cross combinations of three batteries, acted on by keys, as in a piano. The key a being depressed brings simultaneously into circuit the three positive currents; b brings into action the positive current of battery 1 and 2, and throws battery 3 out of action.

Another application of this principle to a reading alphabet consists of three pendulums, each carrying screens, with orifices pierced so that by each combination (bringing the screens into twenty-seven different relative positions behind one another) only one orifice shall be exposed, showing the desired letter. This principle is also applied to printing telegraphs; thus, no type can be pressed till three conductors conspire, and these are directed and insured by the three positions of the needles, and, which comes to the same thing, by the combinations of the three currents creating twenty-seven electro-magnets.

Highton, patent of 1850. Use of a permanent magnet to keep up the magnetism of a soft-iron moveable magnetic needle (as a security against lightning destroying the magnetism of this needle), by continually remagnetising it. A lightning strainer is also exhibited. The circuit-wire, covered only with bituminous paper, is made to pass through a box of iron filings. This is found to be insulation enough for the galvanic current, but not for the tension electricity of lightning, which is therefore carried into the earth by the filings.

The use of the secondary battery, the $3^3 - 1$ combination principle, is made applicable to printing, by touching keys carrying the letters to be printed; and a patented application of the chemical principle, that sulphate of alumina in solution may be advantageously used, instead of sulphuric acid, to keep the battery in action.

A Prize Medal was awarded to the British Electric Telegraph Company for the exhibition of their ingenious telegraphs.

Henley (No. 428) exhibits two powerful compound linear bar magnets. The electric force is produced by a semi-rotation of a double electric coil and armature opposite either pole. The movement is extremely simple and neat, and the shock delivered very powerful. It has worked through 560 miles of wire, also through 60 feet of water. Experiments on the Serpentine were made, when several feet of the wire under the water were stripped of the gutta-percha coating without dissipating the current; and when (as the Jury were told afterwards), on further trial, the wire was divided under the water, yet the shock passed between the ends sufficiently to deflect the needle effectually.

The principle of using permanent magnets as a substitute for a battery is not new. At Göttingen, in 1839, Sir John Herschel was present when Gauss telegraphed from his house to his observatory by its means.

This is a double-needle telegraph, but the needles move only in one direction. The magneto-electric current employed actuates electro-magnets, the armatures of which carry the index-needle, and move it as they move. These currents do not need so good insulation as do battery currents.

A Council Medal was awarded to Mr. Henley.

J. BRETT (No. 429) exhibits an electric printing telegraph, which consists of two parts, called, by Mr. Brett, the communicator or key-board, and the printing machine; the former is supposed to be at the station from which intelligence is to be transmitted, and the latter the place to which it is to be sent.

The machinery is propelled chiefly by the power of weights, or by ordinary clock-springs. The motion of the printing-machine is regulated by the galvanic current, by means of an escapement, and which requires much less power than is necessary to impel the machinery; thus both the advantage of the instantaneous action of the current, and the greater power of the weights, combine to accomplish the work for which this machine is designed.

The key-shaft is about five inches in length; the finger-keys act upon pins by means of rods and levers. The circuit-wheel is fixed to the axis of the key-shaft, which works upon a hollow axis with ratchet wheels and clicks, so as to move forward in one direction with the circuit-wheel. Immediately after it has revolved the desired distance, a number of points, to correspond to the letter or character indicated by the finger-key, and required to be printed by the printing-machine, are released and return to zero, by means of a pulley and weights, independently of the circuit-wheel. The type-wheel is so attached to the key-shaft that a message may be printed in duplicate.

There is another arrangement by which the type-wheel or wheels is attached to a hollow axis, which carries the type-wheel backwards or forwards by a pinion acted upon by a train of wheels in connection with it: this train communicates motion to an arbor, to which a disc is fixed firmly: against the disc a ratchet-wheel is placed, mounted loosely on the arbor, between a fixed washer, and adjusted by a spring-catch, so that it can turn a short distance only on its axis. A slot is cut in the disc of this ratchet-wheel, and also through the adjoining disc, in which a pin works, connected with the tail of a click: this click is so adjusted as to catch into the teeth of the ratchet-wheel. Therefore, when the click is locked into one of the teeth, it causes the type-wheel to travel with the axle and pinion; but when the click is released, the type-wheel returns to zero, by the assistance of a pulley with cord and weight, or of a spring connected with the hollow axis. A lever is put into action by a pin attached to the common wheel of the printing train of wheels, and by its means the type-wheel is returned to its starting-place immediately after a letter or sign has been printed. Mr. Brett considers this arrangement very important, as it insures safety from the derangement to which the type-wheel, by a continuous step-by-step movement, is liable, on account of the accumulation of errors, arising either from atmospheric or other causes. From the momentary effects of lightning or atmospheric influence the machine immediately corrects itself, and the sense of the subsequent correspondence is not disturbed.

The train of wheels which give motion to the type-wheel is controlled by means of a secondary train of wheels, fixed to the back of the frame-plate, which controls and reduces the force of the escapement, and relieves the galvanic or magnetic power required for its regulation.

The type-wheel upon this arrangement may have any desired number of letters and characters without retarding the operation, as they would be so economically placed in the order fitted for their general application. Mr. Brett has adopted an arrangement of letters on the type-wheel in the order of frequency of occurrence. The arrangement is as follows:—*e, t, a, i, o, n, s, h, r, w, a, l, c, f, m, e, u, b, g, p, j, y, k, v, x, q, z.*

In Mr. Brett's patent of 1845 the key-shaft was worked by means of a bevelled friction-wheel, set in motion by a train of wheels and a weight. The barrel was made the length suited to the number of the finger-keys, and the pins were fixed in an uniform helical row, extending its entire length. In the arrangement exhibited, the circuit-wheel is fixed to the end of the key-shaft, as before stated. Connected with this wheel are two pieces of metal, which form the conductors of the current; one of these rests upon the periphery and the other upon the collar of the circuit-wheel, being alternately upon one of the teeth and over one of the spaces. Whilst resting on the tooth it completes the circuit, and when over a space the circuit is broken, and so on, alternately.

In connection with the printing train of wheels of the printing-machine, is an eccentric or cam-wheel, which revolves upon the shaft and is connected with an hydraulic regulator; so that when a piston is raised by the revolution of the type-wheel, a partial vacuum is formed in the valve-chamber, and water passes through holes into the chamber, and momentarily takes off the dead-weight of the piston, and some of the friction of the lever, from the escapement. On the type-wheel being arrested, a lever descends, releases the cam-wheel, and the paper is pressed against the letter upon the type-wheel.

Plumbago or vermilion is preferable in use to printing-ink, as it does not require replenishing for a considerable time.

Mr. Brett also exhibits a small instrument which he calls a pocket communicator, designed for the use of guards of railways, to communicate with the nearest station on the occurrence of accidents, or on assistance being required. In use it is placed in connection with the lines on the railway, and a galvanic battery on the tender, the wheels of the carriage completing the circuit.

It consists of an axle, to which is fastened a ratchet-wheel, over which is fixed a circuit-wheel, with teeth and spaces suited to the number of letters and characters required. On its face is placed another ratchet-wheel, which causes the circuit-wheel to rotate when the click is put into operation, by moving forward a handle, connected with which is a pointer, by which the letters or signs are pointed out.

The arrangement admits of a double circuit-wheel being employed, for the purpose of reversing the poles of the battery, and thus changing the direction of the current of electricity.

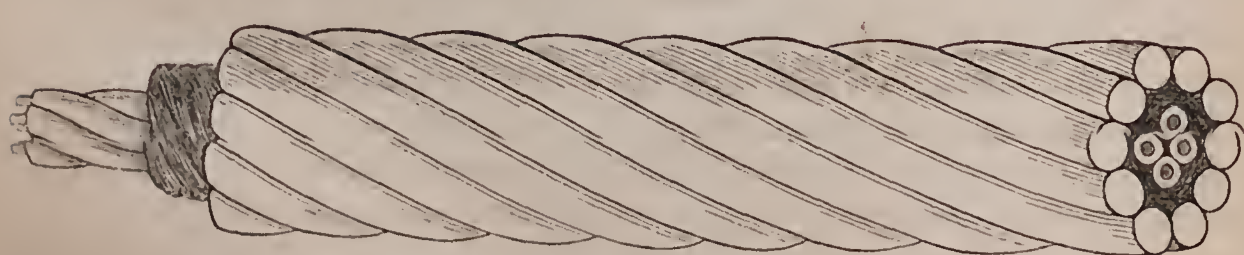
An electric circuit regulator is also exhibited by Mr. Brett. Its purpose is to give a controlling power over all the stations on any line of electric telegraph, so that any important telegraphic information could be transmitted to one or more distant or intermediate stations, without the knowledge of such communication transpiring to any other place than the one intended; the other stations on the line being put out of circuit for the time, by means of a separate wire in connection with a very small apparatus at the different stations. This apparatus it is necessary to construct with a full knowledge of the number and relative importance of the stations upon the line, for the purpose of making the calculations correctly: it will be necessary to exemplify this. Take, for example, five stations,

—London, Dover, Calais, Amiens, and Paris; and suppose the remaining stations to indicate upon the dial an *universal* communication with all the five stations. Ten other divisions will give all the changes of one station to another, thus:—London to Paris, London to Dover, London to Calais, London to Amiens, Calais to Amiens, Calais to Dover, Amiens to Dover, Paris to Dover, Paris to Calais, Paris to Amiens and London, Calais and Paris; making in all twelve points or changes. At each of the stations should be a small apparatus having a dial, similar to a watch, having indicated upon it the number of points, or the names of the respective stations. At the number indicated a small hand or pointer would show that station which was engaged with another in the occupation of the line, as all these would be acted upon simultaneously; and thus any unnecessary interruption would be prevented.

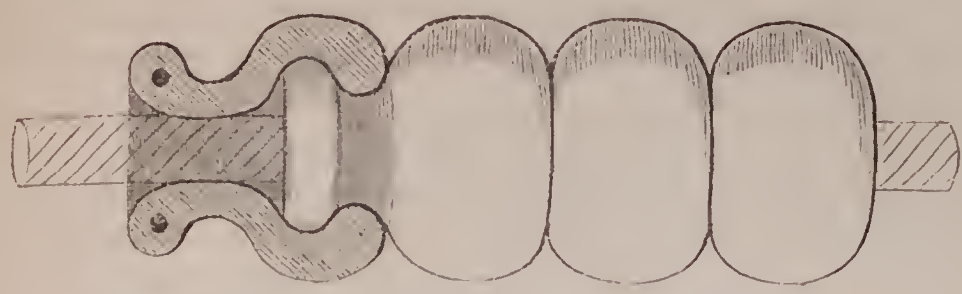
By the use of Mr. Brett's telegraph, communications are made in any language, and printed upon paper with considerable rapidity and precision: the paper and ink are self-supplying, and sufficient may be placed in the apparatus of both to last for some time. Mr. Brett says, that the letters may be printed at a greater speed than a well-practised person could write them, and that a clerk, after some experience, might manipulate upon the finger key-board upwards of 150 letters per minute.

Mr. Brett has also exhibited a specimen of the line used in the first experiment, across the Dover Strait, after having been submerged in very deep water, for more than six months, and is part of the same wire through which the first galvanic current was transmitted from the coast of England to that of France. The experimental line was formed of a single copper wire, insulated by a layer of gutta-percha about five-eighths of an inch in diameter.

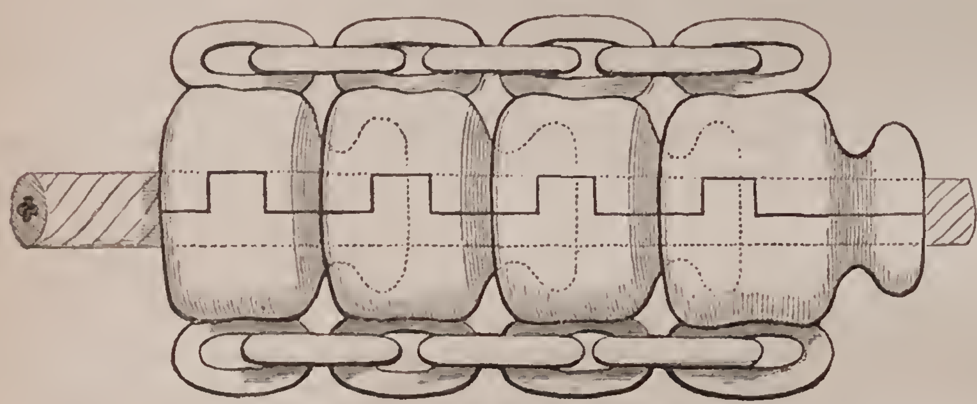
Mr. Brett also exhibits a specimen of wire cable. This is a portion of a permanent line, now being laid down from the South Foreland to Sangatte, near Calais; the core of the cable is formed of four copper wires (No. 16), each of which is insulated and covered with two separate layers of gutta percha. As in the experimental wire, the tightening of the line elongated it to a considerable extent, and caused the gutta percha to divide, so destroying the perfect insulation of the wire; it was therefore resolved to obviate this source of failure by twisting the four wires together spirally, before encasing them in the hempen yarn, well saturated with tar and bituminous compounds, with which they are completely enveloped. The core thus formed, is protected by ten galvanized iron wires (No. 10 gauge) twisted together, the whole composing a cable 1½ inch in diameter, as shown in the annexed cut.



Mr. Brett also exhibits a vertebrated iron tubular cable. This is designed to protect a cable of submarine telegraphic wires, when situated near the sea-coast, from sustaining damage by anchors, or by casualties likely to occur when situated in the vicinity of shipping, and may be made of great strength, and of considerable curvature, without either damage or derangement, as in the following figure.



One of the iron cables exhibited, is constructed with the addition of a chain of links, for the purpose of giving a greater degree of strength in dangerous situations, as shown in the annexed figure.



A Council Medal was awarded to Mr. Brett.

BAIN (No. 434) has exhibited an electro-chemical telegraph, depending, like that of Mr. Bakewell's, on the development at a distance of the chemical effects of electricity. The effect produced is the precipitation of Prussian blue on paper, duly prepared by impregnation with prussiate of potash and weak acid, on the contact of a steel pointer, at the signal station; this contact being determined by the attraction of an electro-magnet on the arm which carries it. The breaking and renewal of contact at the station of departure are effected by the interposition of a band of paper, drawn uniformly along by clock-work, and punched out in holes and slits of different lengths, which allow of more or less prolonged contacts, in conformity with a conventional alphabet. At the station of reception, a large circular disc of the prepared paper is made to revolve uniformly, by simultaneous clockwork, while the iron point, which on every renewal is pressed into contact with the paper, is carried to or from the centre current uniformly by a screw motion, along a line to the centre of the disc, and leaves traces on the paper, as it passes beneath it, in Prussian blue corresponding to the stamped line in the original paper band, and which may therefore be read off at leisure. Other preparations, such as that of starch with iodine, potash, &c., may be used for preparing the paper. There is much mechanical ingenuity and skill displayed in every part of this apparatus.

A Council Medal was awarded to Mr. Bain.

BAKEWELL (No. 433) exhibits a copying electric telegraph, which is fully described in the Illustrated Catalogue, with the method of use, excepting the mode of transmitting invisible messages, which is effected by using paper moistened with diluted acid alone, when a deposition of iron from the steel point is made on the paper without any mark, the writing being subsequently made visible by a solution of the prussiate of potass.

A Council Medal was awarded to Mr. Bakewell.

WALKER (No. 430) has exhibited a *mode of insulation* of telegraphic wires. The great practical difficulty in telegraphic operations, is to overcome the defective insulation consequent on the dampness of the climate. To speak first of the wires suspended in the open air—Mr. Walker has substituted for the old form of cone, to which there were many objections in practice, a large open-mouthed cone, or rather hollow double cone, so constructed that the wire and the cone should be in contact at the smallest possible surfaces; also that, as the place of contact is as far as possible withinside the cone, it should be as inaccessible as possible to wet; also from its shape, that any wet attaining to the cone, would by mere gravity run away from the place of contact; also that the part of the cone, where in contact with the wire, should be at the furthest distance from the timber of the pole sustaining all. After suspending the wires, Mr. Walker has the cone covered in with a roof, having sides and ends.

The wires from Red Hill to Shalford, a distance of 19 miles; from Ash to Reading, 19 miles; from Ashford to St. Leonards, 28 miles; and from Tunbridge Wells to Robertsbridge, 15 miles—are all suspended in this way. These lines are remarkable for their perfect insulation and good working order. It was feared that the birds would build nests in the roofs, but such, as yet, has not been the case. This plan involves no additional expense.

I. In regard to tunnel wires. The deposit of damp and dirt on the suspension apparatus of Mr. Walker's tunnel wires, on the South-Eastern Railway Company's lines, as first erected for him, caused so great a loss and distribution of the voltaic force, that without some improvement a total obstruction of telegraph business would have ensued, and messages to Dover, instead of passing direct, must have been transmitted through an intermediate station.

About the time that Mr. Siemens, of Berlin, was contriving wire covered with gutta percha, it occurred to Mr. Walker to direct Mr. Foster's attention to that substance, and to request that a specimen should be prepared for him. The result was, that Foster obtained a patent, of which the Telegraph Company have the monopoly. It was first used in Mr. Walker's tunnels, where, instead of the old mode of suspending, it is now laid in a grooved board covered in. The grooves are ploughed by machinery; the board is prepared with mineral varnish, and is secured close to the tunnel walls, remaining, when once nailed on, in good working order, and in a perfect state of insulation. This grooved board, simple as it is, will doubtless prove a valuable invention, and those who have felt the charge of badly-insulated wires will appreciate the improvement. Compared with suspended wires, it is important to the safety of trains and passengers. The old wires have many times been entangled with trains, not only being torn down, but putting the lives of all exposed in jeopardy. Several narrow escapes of this kind have occurred. The last tunnel on the South-Eastern Company's lines, that between Higham and Rochester, is now being fitted up with grooved boards; and this board is used on all sustaining walls, of which there are many on the North Kent line; in leading in to stations sometimes down the wall, at other times under the floor. Being prepared by machinery, it is not at all costly.

II. *Compound Needle.*—The first telegraphs made were furnished with long coils and needles. Mr. Holmes introduced the needle, now in general use, in the form of a rhomboid, with a much smaller coil of silk-covered wire. By means of this improvement, legible signals are obtained through longer distanees, and can be conveyed very rapidly and distinctly. But the great inconvenienee with this needle is the readiness, as we have already mentioned, with which it parts with its magnetism, losing it by little and little during the ordinary nse of the instrument, at times suddenly and often totally when lightning discharges occur near the wires. With a view of obviating these ineonveniences, Mr. Walker has substituted for it, in the same small coils, an ivory disc, having several short rectilinear needles placed side by side upon it, and at small distances apart. These needles possess all the good qualities of the rhomboidal; but they give a more dead beat, and are less disposed to part with magnetism. They have not been yet tried *in extenso;* but Mr. Walker has tested them for long periods at important stations, and is now about to use them extensively, on account of the serious interruption that has occurred simultaneously in all parts of the country from loss of magnetism. During this summer it was not of unfrequent occurrence to have two or three magnetizers, travelling as rapidly as possible from station to station, to re-magnetize; and sometimes before their day's work has ended, demagnetization had again occurred at some stations.

III. *Bell Transferrers.*—This application is not generally employed, and is constructed specially for the ehief office at Tonbridge. It is for placing the bell, when one part of the line is in use between London and Dover, on the part or side not in use, so that its ring may be heard, and thereby notice given that the line is wanted. By this arrangement the necessity of cutting short the communication, or rendering it as brief as possible, is indicated.

The bell and needle being on the same wire, this wire is cut at Tonbridge in the three proper places, viz., between London and the bell, between the bell and the needle, and between the needle and Dover, making six ends. These ends are made to terminate in springs, which rest on brass plates, inlaid in a wooden cylinder. In one position of the cylinder the springs are connected in the order—London, bell, needle, Dover; so that when talking to Dover, having the line cut off between the needle and the bell, by connecting the wire here with the earth, the bell can be heard to ring, should London send a current along the wire. In the other positions of the cylinder the springs are connected in the order—London, needle, bell, Dover; and similar advantages are experienced in respect to Dover. This plan works well. On the same principle of combination Mr. Walker eonstructs all his turn-plates, of which he has many varieties: the following is one:—

IV. *Branch double Turn-plate.*—This apparatus is used at junction-stations for putting branch lines of telegraph in communication with either end of a main line. It is constructed by intercepting the branch wires before they terminate in the earth, and by cutting the main wires and providing springs at the intersections.

The springs are so arranged that, in the normal position of the drum or cylinder, the terminal stations of the main line are open to each other, and the branch line terminates at the junction-station. In another position of the drum, the London terminus of the line is connected with the branch line, and the wires from Dover end at the junction-station. In a third position of the drum, the Dover terminus is in connection with the branch line, and the wires from London end in the junction-station. This is in daily use at the stations on the line, and acts well.

V. *Lightning Conductor.*—This consists of a small hollow metal cylinder connected with the earth, its purpose being to conduct away the discharge. The line-wire, in its passage from the railway to the telegraph, passes within this cylinder; traversing which it is first presented to the inner surface in the condition of a thick wire, furnished with spurs, whose points are in the closest possible proximity to the cylinder, without being in actual contact; it is then continued on and presented as a short coil of very fine wire—finer, in fact, than that of the instrument coils, wound on a bobbin—the outer convolution of the coil being very close to the cylinder. Thus a better means of escape is presented to the lightning than is to be found in any part of the instrument, consequently it always escapes by this conductor either through the points or by burning the fine wire. As yet no instance has occurred in which these conductors have failed to act, and to preserve the instrument; while instruments in the same office, not thus protected, have on several occasions been damaged.

VI. *Graphite Battery.*—The ordinary telegraph battery consists of plates of amalgamated zinc and clean copper, in cells filled with pure sand, saturated with diluted sulphuric acid. The majority of telegraph batteries are in actual use during a small portion only of each day, remaining at rest for the remainder of the twenty-four hours, ready for use and in good working order when required. During this time of inactivity there is a continuous slow action between the diluted acid and the copper, whence is produced sulphate of copper, which in its turn becomes decomposed, and the copper released upon the zinc, induces local action, greatly reducing the power of the battery and destroying the zinc, so that it requires to be changed and cleansed more frequently than would otherwise be the case. To obviate this, Mr. Walker sought for a substance that might possess the good properties of the copper-plate, but which should not be acted upon by the acid. The corrosion deposited on the interior of old gas retorts is admirably adapted for this purpose, and he has had it cut into plates by circular saws, worked by steam machinery. He has preserved the history of a 12-plate battery, which was connected up to do telegraph duty, where the waiting-time was very great as compared with the working-time. It was charged in the usual way, with diluted sulphuric acid, on April 5, 1849, and remained efficient till the middle of February 1851, without having been washed or having had the sand changed. It was supplied with about a dessert-spoonful of acid water twenty-one times during the above period of ninety-seven weeks, and six times with merely warm water. It suffered most from mere evaporation: in some cases it did duty for thirty-four, thirty-nine, and forty days, and in one instance for seventy-seven days, without having been touched. On September 15, 1851, it was dusted and had a little acid water poured in, when it still gave a feeble working current.

VII. *Moveable Studs.*—This is a very simple arrangement, and originated with Mr. Walker. The motion of the telegraph needle is limited within a certain angle by two small ivory studs. In the year 1848 there were so many magnetic storms and other abnormal conditions, that the needles were very frequently deflected in either direction, and often hard up to the studs, so that the power of deflecting in that direction for the purpose of signalling was lost, the needle being already there; and thus the telegraph was rendered nearly useless—indeed quite so in the hands of inexperienced clerks. To remedy this, Mr. Walker has mounted the studs on a circular and moveable disc, so that, in proportion as the needle is deflected abnormally, the studs may be moved after it by the motion of this disc, and the needle, though not hanging vertical, may still maintain its position of equilibrium midway between the studs. This contrivance works well, and the Telegraph Company have adopted it.

VIII. *Ringing Handle.*—This is used at stations where the bell has a distinct wire to itself. It enables an intermediate station to send the electric force in the direction only of the station whose attention it is required to call. This improvement is Mr. Walker's, as are also the essential details of the apparatus; before the introduction of which it was found difficult to keep the circuit good. The line wires are cut between the ringing key and the bell, and strong springs are inserted, which press on brass studs and keep good the circuit when the apparatus is in a state of rest. To the handle is attached a moveable cylinder, furnished with two strong studs in proper connection with the respective poles of the battery. By moving the handle, one of these studs, and consequently one pole of the battery, is put in connection with a strong brass boss, connected by a wire with the earth, and the other stud, according as the handle is moved to the right or to the left, raises the spring on either side the bell, and sends the current up or down the line, as the case may be. This arrangement is used throughout the South-Eastern Company's lines, and works well.

A Prize Medal was awarded to Mr. Walker.

Allan's Patent (No. 201) consists of a circular dial plate, arranged in a sloping position, with an alphabet and a pointer, which by a handle is brought round to the letter required; at the same time it makes, breaks, and reverses the current. By this means the pointers on the second or telegraph dials are made to indicate the same letter at distant stations.

The chief feature is the form and disposal of the many-poled permanent magnet which works the ratchet-wheel arrangement, thereby giving motion to the pointer or index of the telegraph. The power in this instance is created by two electro-magnets, having their poles projecting between the arms of the many-poled permanent magnet, each pair of arms being so magnetized as to act collectively in conjunction with the poles of the temporary magnets; by this means the frame acting upon the ratchet-wheel is made to alternate in coincidence with the changing of the current, and so cause the axis of the index-hand to rotate.

To impart a rapid movement to the index-hand, the current-changer is formed of three metallic discs, insulated from each other, and so arranged, as to the number of letters on the dial-plate, that the current is made, broken, and reversed, accordingly, and causing the index-hand to pass round at once to the letter required with great rapidity.

Allan's needle telegraph consists of four electric cylinder coils, placed between the arms of a many-poled magnet of four pair of arms. Each arm of each pair is magnetized so as to possess the same polarity: thus when the current passes through the coils, the combined magnet is attracted or repelled in either direction, according to the movement of the current, thereby giving deflection to a needle with great rapidity and precision.

The system developed by these improvements consists in forming magnets out of one piece of steel, with any number of poles required, and placing cylinder-coils, or electro-magnets, between the poles, thereby not only obtaining a much greater amount of magnetic power within a small compass, but also a greatly-diminished resistance to the electric current: as each turn of wire in each coil is so placed that the current passing is within effective influence of a magnetic pole, none is lost, whilst the length of wire, and consequent resistance, is greatly reduced; the action, too, being direct, likewise prevents the loss or waste of the current power.

The great advantages gained by these combinations are shown by the fact of there being surplus power sufficient to overcome the friction of the ratchet-wheel arrangement, without the assistance of weights or machinery, also with as little battery power as the common needle telegraph now in use.

A Prize Medal was awarded to Mr. ALLAN.

DERING (No. 436) has exhibited an electric telegraph. Mr. Dering suspends his indicating magnet (which is deflected), not by the simple action of the current, but by coil-magnets on either side, so as to have its centre of gravity below the points of suspension: either by elastic bands, by the attraction of a permanent magnet, or by such an adjustment of a strait bar, or pair of watch-springs, as shall give it a decided tendency to a vertical position when not under lateral influence.

Mr. Dering has also exhibited an apparatus for conveying secret signals without extra wires; viz., signals which shall be read off only at given localities without passing along the whole line included in the primary wire. This he has accomplished by placing at each station a step-by-step revolving disc, included in the primary line of wire, but so arranged as not to be set in rotation except by a galvanic force greatly superior to that which makes the ordinary signals; or, when only currents in one direction are used for these signals, then by the reverse current. This disc, being brought at every station to correspondence in point of position with its position at the initial station, is made, by a system of non-conducting interruptions to the continuity of its circumference, to establish a break, according to its position, cross connections, or *short cuts* by which the signal current can pass (and therefore will pass) from one point to another of the primary line of wire, without running through the length of wire constituting the local working coil of the station, so that the working of the telegraph at that station is temporarily suspended, the electricity finding for a time a shorter and easier passage. Besides this ingenious contrivance, Mr. Dering has exhibited modes of preventing the disturbing action of atmospheric electricity and the destructive effects of lightning.

Mr. Dering considers—

I. The steel best suited for the electric magnets is that employed to form the balance-springs of watches.

II. As regards the mode of suspension for single telegraphic needles, instead of suspending the needle in a round hole by a round pivot in the middle, or nearly so, Mr. Dering finds it in all cases better in practice to use a triangular-shaped hole at the *upper end* of the needle, with a round pivot on which to suspend it. This allows freedom of motion quite sufficient, whilst it entirely checks vibration. The instrument on this principle exhibited, shows the great rapidity in the change of place of the needle combined with freedom from vibration.

III. By a peculiar arrangement of coils for producing motion in telegraphic needles, with the same number of convolutions, the total length of wire is lessened, and thus the battery force required is diminished.

IV. In the apparatus for the transmission of secret messages, by throwing stations out of the line of communication, there is a means provided of instantly restoring the revolving discs at any moment desired, and from any position, to the starting point.

V. In case of a telegraphic needle being deflected by the aurora borealis, or other slight atmospheric influence, Mr. Dering places in the circuit of the line-wire a battery of sufficient force (regulated by the number of galvanic elements) to counteract the disturbing influence, and thus restore the needle to its ordinary position of equilibrium.

VI. An instrument for protection against atmospheric electricity is also exhibited, as described under the eighth head of specification in Mr. Dering's patent. In this the size of the balls may be increased to any extent, provided their distance from the opposed plates be in a proper proportion diminished. This would prevent the chance of the destruction of any part of the safety apparatus.

The Jury considered Mr. Dering as deserving of very Honourable Mention for the great ingenuity he has displayed in these inventions.

Brett (No. 422) has exhibited a patent electric telegraph alarum bell, bell-handle, and battery. The various letters or numbers represented on the face of the dial of the electric telegraph are made by the motion of either or both of the indicators, the number of which motions for each letter or number is defined by the figures on the centre of the dial, commencing at all times with the indicator on the side next the letter or number, and when both indicators are used finishing with the opposite one. The helices being double and of a circular form, the greatest amount of electricity is concentrated in their centre, and the magnet being in the form of a ring or horse-shoe, suspended in the centre of the helices, its poles are acted upon by the maximum amount of force, by which great certainty is attained, and the magnet is deflected to the right or left according to the direction taken by the current. The poles of the magnet being equidistant from the earth, the magnet is rendered static, and is not affected by terrestrial magnetism.

Little suspends a common sewing-needle within a tube containing alcohol by means of a permanent magnet at the upper end, so that it can deflect without friction, and does not jar against the electro-magnetic coil on either side which deflects it, while the permanent magnet keeps up the magnetism of the needle.

Alexander (No. 426) exhibits a model of an electro-magnetic telegraph, described in the Illustrated Catalogue. It is interesting as representing an early development of the idea of a needle telegraph. It has 30 line-wires, 30 galvanometers, and 30 needles; the latter carrying each a paper screen, which, when moved, unveils a letter, &c. The galvanometers are not calculated for actual work in real practice; and, as only one wire is used as a return wire, common to all the galvanometers, there must follow a distribution of electricity among the rest of the wires, fatal to real signalling. The earth is the return circuit in all practical plans.

SMITH (No. 424) exhibits a comic electric telegraph. This is a three-wire telegraph, and the author considers that, by three combinations, all that is necessary in telegraphic communications can be performed.

McNAIR (No. 421) exhibits specimens of electric-conducting wires for subaqueous purposes. The process of making this wire is by first placing a coating alternately of gutta percha, or caoutchouc, and braiding of cotton-thread, till the cumulation is of a given thickness: after which it has an outer coating of gutta percha, and is then placed down a hollow mandril, and, by means of a great hydraulic pressure, a lead covering is placed around it, embracing it so firmly that the whole is one compact body. This article seems to answer its purpose well; and, although there were many specimens of subaqueous wire in the Exhibition, yet, for the most part, their base is Mr. McNair's wire.

WHISHAW (No. 419) has exhibited well-made gutta-percha tubes, furnished with ivory mouth-pieces, useful for talking across rooms, or in a railway carriage, or for deaf persons: an early specimen of gutta-percha tubing and lathe-bands: submarine, insulated electric copper wire, covered with gutta percha, braided with linen, and painted or varnished. These specimens would not bear the wear and tear incident upon the knocking about they would meet with. A long wooden box, to be used as a battery protection; a private code-box—this is a box with a sloping front perforated with slits; letters are arranged vertically on the side, and horizontally on the top. Within the box are as many rollers as there are slits in front, around which are wrapped long bands of paper, each having a communication printed thereon, and repeated many times. The end of each band projects so that it may be easily drawn out. By looking at the two letters corresponding with those sent from the Telegraph Office, the communication is at once discovered. A model to illustrate the hydraulic telegraph. The hydraulic telegraph was invented in the year 1837, and from that time there have been several modifications; some have been furnished with floats and indexes carrying letters, &c; some with floats and metal-rods, which, on being either elevated or depressed, point to letters, &c. A reservoir for the supply of the water and a tank for the waste are required at each station. In the model exhibited, a siphon-tube shows the application of the water itself, which rises and falls in the tubes by opening or closing the respective cocks. Patent glass tubes, to insulate and protect the wires of the electric telegraph when placed under ground. The use of these would be found to be expensive, and probably hazardous.

Patent multi-tubular pipes, of glazed earthenware, well made; their use is to insulate and separate the wires of electric telegraphs when placed under ground. Probably these would be perfectly insulated with gutta-percha wires, but if broken there would be some difficulty in replacing them. The desiderata are, great durability and great accessibility.

Wrought-iron pipes, with ball-and-socket joints. The length of each pipe is

2 feet, and allows an inclination of about 10 degrees, forming a subaqueous chain for protecting electric telegraph wires when under water. This arrangement seems to be good.

This completes the British portion of the exhibition of electric telegraphs, and from it a very good picture of the English systems of telegraph is presented. One out of the only two specimens which have been sent from abroad is that of Siemens and Halske, Prussian system, and which we proceed to describe:—

SIEMENS & HALSKE'S (Prussia, No. 310A). The telegraph exhibited by these inventors is extremely ingenious, and the construction and details are very good. It differs essentially from all others that have fallen under our notice, in that signals are made by arresting, instead of by causing, the passage of electric force. It consists of three parts,—an alarum, an indicating dial, and a printing arrangement. The force is derived from voltaic batteries. Daniell's constant battery is employed, twenty-five pairs of which, at each station (for the batteries at both communicating stations act in concert), are said to act through about 250 miles of wire. The force, in all cases, is made available by means of electro-magnets. And, first, in respect to the arrangement, when no communications are passing, but the stations are each in a condition to receive notice that they are required to attend. The bells alone are left in the circuit. When a current passes along the wire, the keepers of the electro-magnets, which are on one arm of a lever, are attracted, which causes a small hammer on the other arm of the lever to strike a bell. The clerk, who desires to call attention, turns his own bell out of circuit, by moving a lever, and at the same time turns his battery and his telegraph instrument into the circuit, and then leaves them. This allows the electric force to have free course, and the distant bell to ring; but the electro-magnet of the alarum is so adjusted that the circuit becomes broken the moment the armature leaves its normal position, which it does by the attraction of the magnetism: the magnetism, therefore, ceases with the cessation of the current, and the armature returns again to complete the circuit; and so on alternately, producing a succession of blows upon the bell. During this time, the telegraph instrument of the first station, although in the circuit, is perfectly inactive; being so arranged that its electro-magnet is much less sensitive than that of the alarum, its armature requiring more electric force, or more time to acquire motion, so that the circuit is broken by the action of the alarum before the telegraph has been able to move. When the sounding of the bell has gained attention at the distant station, the officer in charge there turns his alarum out of circuit, and introduces his telegraph instrument and his battery. There are now in circuit a battery and an instrument at each station, which are so arranged that the two batteries combine to produce a current in one constant direction, and hence both act simultaneously on both instruments.

The instrument presents a circular dial, around which are engraved the letters of the alphabet, or other conventional signals, and is furnished with an index, which, under the conditions above named, continues traversing the circle at the rate of about thirty times per minute. The two (or more, as the case may be) instruments act precisely in concert, which is thus accomplished.

The armature of the electro-magnet carries a lever, at the end of which is a claw; that advances one tooth of a ratchet-wheel (mounted on the same axis with the index) at every attraction. But this armature breaks the circuit at each attraction; and the magnetism ceasing, it is returned to its normal position by the action of a slight spring, again to complete the circuit, and to draw on one more tooth of the wheel, and cause the index to advance, and so on. All things being in order, the alternate making and breaking of the circuit is simultaneous on each instrument, and the indices of each point to similar letters at the same time. In order to turn this arrangement to account, the dial is surrounded by a circle of studs corresponding to the respective letters. On pressing any one of these down, it impedes the progress of the ratchet-wheel just at the time when the circuit has become discontinuous, and no current is passing. The index, therefore, of each instrument rests at the letter in question, and continues its course only when the stud is allowed to return and the wheel is liberated.

With the following additions, this instrument becomes a *printing telegraph*. The ratchet-wheel is furnished with radii, consisting of springs, each having a type-letter at the end, directed upwards. In the revolution of the wheel, these types pass between a hammer below and a blackened cylinder above, and between the type and the cylinder passes a band of paper. The hammer is on one arm of a lever, the other arm of which carries the armature of a supplementary electro-magnet, which magnet is in the same circuit with the magnet of the indicating instrument. A current passes through the two simultaneously, but is so instantaneously cut off, that the magnetism has not had time fully to develop itself and to attract the armature; but the act of depressing the stud, which causes the index to rest for a moment at a given letter, is contrived to keep the circuit of the printing magnet complete during the same interval, and so to allow the full development of its magnetism and to cause the attraction of its armature. The type-letter in question is at this moment between the hammer and the paper band. The armature, being powerfully attracted, causes the hammer to strike a smart blow upward, and then to press the paper against the blackened cylinder, which prints the form of the letter. Letter after letter is thus printed, and a blank is touched at the end of each word. When the blanks are struck, the hammer, meeting with no resistance, moves a little further, and enables a lever attached to it to reach a bell, which was beyond its former limit, and thus the sound of a bell is heard at the end of every word. At the same time that the hammer strikes a letter it breaks the circuit of the printing magnet, and thus liberates itself, and returns to its normal position the moment its work is done.

The lever that carries the hammer is likewise provided with arrangements for advancing the paper the width of one letter as it returns to its position of rest, so that the letters follow in due succession: it also advances the blackened cylinder in the direction of its axis, so that it shall not become exhausted by always printing from the same surface.

There are other arrangements provided for facilitating the transmission of electric force to long distances, and for overcoming some of the difficulties that occur in practice.*

A Council Medal was awarded for this beautiful system of telegraph.

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* For a full description of Siemens and Halske's telegraph, with plates, see Schellen, Der Electromagnetische Telegraph, Braunschweig, 1850.

The remaining Foreign Exhibitor.—

Stöhrer (Saxony, No. 15) exhibits a magneto-electric telegraph. It is applicable to the ordinary use of telegraphs. In practice the hand always turns the same way. Attached is an alarm bell, which is readily put in and out of connexion.

A Prize Medal was awarded to Mr. Stöhrer.

Domestic Telegraphs.

Burdett (No. 245) has exhibited a domestic telegraph designed to supersede the use of bells in mansions, club-houses, hotels, and large public buildings. The machine itself presents a smooth surface or dial, with various numbers indicated upon it. Every room in the establishment with which it is in connection, being numbered, is furnished with a wire attached to the corresponding number of the machine, which has a bell attached to itself. On any one of the wires being pulled, the fact is indicated by the striking of the bell, the indicator pointing at the same time to the corresponding number of the room, which requires attendance, before doing which the attendant should replace it, by pressing down the lever at the foot of the dial; but should several indicators on the face of the dial denote that several wires have been pulled at the same time, the machine is so contrived that he may replace them successively as they are attended to. It is intended to obviate the confusion attendant upon the ringing of a number of bells at the same time, a source of great perplexity to the servants, as the bells having ceased ringing they are deprived of the means of knowing in what part of the house their attendance is required. The machine is by no means unsightly, and is far less expensive than the ordinary fitting up with bells.

Reid (No. 427) has exhibited a pair of electric telegraphs, adapted for the use of hotels, taverns, public gardens, &c.

Also another pair, for railway boards, public companies, manufactories, &c.

A pair of electric telegraphs for domestic purposes, adapted to gentlemen's dressing-rooms, libraries, or ladies' boudoirs, &c.

Also an electrical apparatus for ringing bells in large mansions, hotels, &c. To be brought into immediate action by pulling a cord or lever as with common bells. This instrument is designed to act at great distances with ease and rapidity.

Wishaw (No. 419) has exhibited a domestic telegraph. The dial, which has an index-hand affixed to it, has also engraven upon its face a number of short sentences or written orders for requisites, such as are likely to be called for at the establishment to which the telegraph belongs. The index points to any one of these sentences as required, the communication being established by means of wires and cranks in connection with a clock movement.

Brooks (United States, No. 222) exhibits a bell telegraph for the use of hotels, &c., consisting of one bell, with a series of springs: it seems well adapted for its work.

Howland (United States, No. 486) has exhibited a bell telegraph for the use of hotels, dwelling-houses, steam-ships, &c., and is designed to avoid the complication of bells necessarily employed in large establishments. Each signal on the dial of the instrument is distinct, and remains fixed until relieved by an attendant.

It may readily be attached to the usual arrangement for bells. It is ornamental, and requires but little space.

Chemical Apparatus.

A very small number of manufacturers have contributed to the Exhibition, and, with the exception of Quennessen (France, No. 1683), and Staffel (Russia, No. 148), no great preference can be given to one or the other of the principal Exhibitors. It may, however, be mentioned, that, more or less, the chemical glass and china apparatus, made by German manufacturers, have been exhibited by the majority, which indicates its adaptation to practical use, as might be expected from its greater lightness and durability.

No new invention, except that of Mr. Staffel, nor any new application of known construction of apparatus, is mentioned.

KNIGHT and SONS (No. 453) exhibit a chemical cabinet, containing apparati for laboratories, graduated cylinders, jars, blow-pipes, an improved bellows, pneumatic troughs, chemical tests; lamps, retorts, and other glass articles; apparati from iron and earthenware, arranging furnaces, mortars, &c., being a complete set of articles in daily use by the practical chemist.

This cabinet is intended to combine usefulness with economy: it is proposed that such cabinets should be fitted up with apparati and tests for the agriculturist, the analyst, the commercial man, and the student, with the prices attached to each article, so that the amount of the first outlay being under control, the ultimate expense may be known with certainty, and the difficulty of selecting appropriate and useful apparatus avoided; as well as the necessity of devoting an entire room to the purpose. This cabinet promises to be highly useful.

A Prize Medal was awarded to Knight and Sons for their chemical cabinet.

Knight and Sons also exhibit a chemical furnace on the same principle as that of Dr. Black, which is constructed of stout sheet-iron lined with fire-bricks, and is applicable to nearly every purpose for which a furnace is required; one sand-bath, stoppers, crucibles, muffles, rings, &c.

Knight and Sons also exhibit a galvanic battery, according to the arrangement of Daniell, consisting of a series of six cells, each holding a copper cylindrical vessel, to be filled with a solution of sulphate of copper, in the centre of which is a porous tube, filled with diluted sulphuric acid, and containing an amalgamated zinc rod; also a battery on Grove's arrangement, consisting of a series of six cells, each comprising a glass vessel, containing an amalgamated zinc plate, to be filled with diluted sulphuric acid, having in the centre a flat porous cell, with a platina plate, and filled with nitric acid; also another battery on Greer's arrangement, consisting of a series of six cells, each comprising a glass vessel, containing diluted sulphuric acid; to each cell is a series of three plates, the centre one being of platinised silver plate, and the others amalgamated zinc. These plates are connected to one rod, and can be easily raised out of or lowered into the liquor.

A galvanic battery, on the Maynooth arrangement, consisting of a series of ten cells, each being a cast-iron trough, filled with diluted nitric acid. In each cell is placed a porous cell, charged with diluted sulphuric acid, containing an amalgamated zinc plate.

A galvanic battery, consisting of cells formed of gutta percha filled with sand, saturated with diluted sulphuric acid, each cell containing a copper plate, and one of amalgamated zinc.

Griffin (No. 457) exhibits graduated glass instruments, applicable to the examination of carbonate of soda and carbonate of potash, of all degrees of impurity, ammonia, sulphuric acid, muriatic acid, acetic acid, and vinegar of all strengths, bleaching powder, and bleaching liquors generally; the graduation of these instruments is executed on the principle of assigning a fixed volume to the atomic weights of each chemical compound when in solution, and so producing a series of equivalent test liquors. The standard is made on the consideration that 100 grains of oxygen, in a deci-gallon of solution (being in the proportion of 1,000 grains in a gallon), at the temperature of 62° Fahr., produce a solution of 100°, which represents a quantity of any chemical substance equivalent to 100 grains of oxygen, or its atomic weight expressed in grains, contained in a deci-gallon of the solution.

Thus 503·38 grains of hydrate of soda,
667·34 grains of anhydrous carbonate of soda,
1792·13 grains of crystalline carbonate of soda,

dissolved respectively in water, so as to make a deci-gallon of solution at 62° Fahr., are of the same chemical strength.

In like manner, 643·19 grains of anhydrous acetic acid,
455·13 grains of anhydrous muriatic acid,
501·165 grains of anhydrous sulphuric acid,
2028·64 grains of nitrate of silver,

brought into aqueous solutions of the above bulk at 62° Fahr, are all solutions of 100° of chemical strength. The extreme convenience of this system carried out in a laboratory in respect to the saving of time, thought, and calculation, and its power of securing uniformity of manipulation, must be obvious to every chemist.

The graduation of all the glass measures applicable to these investigations, as well as all others exhibited by Mr. Griffin, is exceedingly accurate and good, the divisions from 10° to 10°, being performed by Ackland's graduating machine, which gives correct aliquant parts. The unit of measure, to which the small measure, called pipettes and alcalimiters, is referred, is termed by Mr. Griffin the *septem*, by which is meant the bulk of seven grains of water, at the temperature and under the barometric pressure at which the imperial measures are regulated: 1000 septems make a deci-gallon, corresponding to 1 lb. avoirdupois of distilled water, and the tenth part of an imperial gallon of water. The septem, therefore, is identical with the milli-gallon.

Mr. Griffin exhibits a set of decimal weights and measures founded on the imperial gallon and the 1 lb. of 7,000 grains.

This Exhibitor, in addition, has given a rich collection of objects, for the most part similar to those exhibited by No. 453, consisting chiefly of apparati for making assays with the blow-pipe, mineralogical boxes, a large collection of graduated glass apparati, applicable to various purposes, boxes fitted with chemical tests, alcalimeters, saccharometers, areometers. In the arrangements made by Mr. Griffin for special purposes, everything necessary has been included, to the exclusion of all else, with especial reference to economy and convenience.

A Prize Medal was awarded to Mr. Griffin.

Edwards (No. 438) has exhibited retorts, phials, and capsules, covered with an electrotyped precipitate of copper, to protect them against cracking by heat; all these articles are good. The covering of glass vessels with copper is not, however, new; but its use would appear to be very little known in England.

The Jury considered Mr. Edwards deserving of Honourable Mention.

Ibbetson (No. 459). Blowing apparatus, constructed with two circular bellows, for the purpose of a continuous blast.

Statham (No. 456). Boxes fitted with chemical tests, in various sizes, pneumatical troughs, &c.

Baker (No. 396) exhibits a saccharometer and lactometer; but it is to be remarked, with respect to the former instrument, that the optical analysis of sugar surpasses all other modes.

Coffey (No. 454) exhibits chemical apparatus. In a few square feet are comprised the means of performing some of the most important and troublesome operations of the laboratory. It contains *a still* (or steam-boiler); with sets of moveable pans for decoctions, extracts, evaporations, steam-bath for retorts, stills, &c., drying closet, a condenser for steam, and worms for other stills, the chamber containing them acting also as a stove and condensing tube. The temperature can be regulated, with great exactness, by means of steam-cocks and valves. An improved feeder, a steam-gauge and thermometer, a safety-valve and alarum, are attached to the boiler.

Johnson and Matthey (Class I., No. 477) have exhibited palladium crucibles and capsules. The use of palladium for this purpose has many advantages. Its infusibility, though not so great as that of platina, is such as to enable it to resist the greatest heats applied in all ordinary chemical operations, while it is not subject, as platina is to a considerable extent, and gold, in some degree, to be attacked and corroded by the caustic alkalis at high temperatures. It is much less fusible than gold or silver, and, like the former, resists the action of all acids. For this valuable accession to the list of chemical utensils a Prize Medal was voted.

[It may not be irrevelant to the subject of this report, to suggest as worthy the attention of chemists, the practicability of coating, by galvano-plastic processes, the interior of clay or plumbago crucibles with films of platina, palladium, gold, or even silver (as the use to which they are to be applied may require), of sufficient thickness and cohesion to withstand a moderate amount of mechanical abrasions, and to intercept the action of saline matter in fusion on the crucibles. Much of the original cost, both of material and fabrication, would thus be saved, and the material might be recovered by acids from the worn-out or broken utensils.—J. F. W. H.]

Horne, Thornthwaite, and Wood (No. 220), exhibit a galvanic machine for medical and other purposes, with a case of instruments for its application. The novelty of its construction, and that upon which its utility depends, is, that the current of electricity produced should be of considerable intensity, and flow in one direction only. It is composed of one coil of stout insulated copper wire. A Smee's voltaic battery, with an arrangement for lifting the plates out of the acid when not in use; and a balance galvanometer, for indicating the strength of galvanic currents by means of grain weights.

Hearder (No. 439) has exhibited a galvanic machine, with a graduated regulator employed to administer galvanic electricity. It is intended to regulate the intensity of the shock by means of two moveable indices, that on the left by advancing over a graduated arc produces equal increments of power; that on the right by moving over an arc which subdivides the increments of the first index into four parts, makes the advance from one extreme to the other gradual. The difference of construction consists in the proper adjustment of the length and thickness of the generating or primary coil to the electro-motive force of the battery, by which the battery surface is much reduced, and a higher degree of magnetism produced in the iron core. The instrument is compact, the bottle of dilute acid being contained in the box of requisites. The high magnetic power permits the use of strong springs which vibrate rapidly: the great range of power is also equally divided. It is the invention of Mr. Hearder, of Plymouth, and is intended for the use of private families. It may be mentioned that a difference of construction has been resorted to for the purpose of increasing the attractive power by means of a small iron rod in the centre of the core, which is employed to exert a more powerful attraction upon the iron armature of the spring, the shape of the armature itself being peculiar.

Taylor (No. 466) exhibits a pneumatic battery for igniting gunpowder, in blasting operations.

Nunn (No. 371) exhibits a hydrometer, capable of ascertaining the specific gravities of all fluids, its range including 0·6 to 2·0. The point of most interest in this instrument consists in the being able to insert certain weights with the instrument below the centre of gravity, thereby rendering its uniform bulk of any specific weight that may be required. By this means considerable accuracy and efficiency are obtained.

Lyons (Class VI., No. 203) exhibits several batteries, and claims improvement for the introduction of wood instead of porous cells, which by rendering the deposition of copper more regular in its action, and more constant in its deposition, constitutes an arrangement by which no copper is lost. In consequence of the action of the sulphate of copper being limited to the surface of porous cells, holes were made in the cells, so that the solution becoming acidulated, acted upon the copper: Mr. Lyons, to obviate this, introduced a gutta-percha tube, perforated with holes, and found the copper clear and equal throughout, also the solution of equal strength both at the top and bottom.

The principle here exhibited is that of economizing the battery power.

Mr. Lyons has also introduced methods by which he makes the usual waste available for battery power, by having two cells of gutta percha, the one fitting within the other, charged with aquafortis; by the introduction of plates of iron on either side, with zinc in the centre, and suitable arrangements, he saves the oxide of copper by its being thrown down. Mr. Lyons has the merit of arrangements whose objects are constant and regular action, cheapness, and suitability to the performance of all that to which electro-magnetism is usually applied.

Quennessen (France, No. 1683). This exhibitor stands first in the exhibition of chemical apparatus, having exhibited a platina alembic for sulphuric acid, containing 250 pints, *made in one piece, without seam or solder;* also long platina tubes, made without seam, besides crucibles, capsules, &c., all of which are executed with the greatest care, and appear to be of the most finished and exquisite workmanship. Among the articles in platina exhibited by M. Quennessen, is an apparatus for the distillation of hydrofluoric acid, of a very complete and perfect kind. A Council Medal was awarded to M. Quennessen.

CHUARD (France, No. 123) exhibits a gazoscope, an apparatus so constructed as to indicate the presence of hydrogen gas, when in an atmosphere containing only $\frac{1}{180}$th part of this gas, that is to say, 1 part of gas to 179 of atmospheric air.

In the year 1843 several engineers were appointed to test the gazoscope, in the coal-mines of St. Etienne, and they reported favourably upon its efficacy in preventing explosions of all kinds during the time of trial, viz., during the months of October, November, and December, 1843. According to Sir Humphry Davy, the proportion necessary to an explosion is about $\frac{1}{14}$th; and, consequently, if the presence of so small a portion as $\frac{1}{180}$th can be shown, its presence would be made manifest long before an explosion could take place.

M. Chuard also exhibits a new safety-lamp, which has been made at the expense of the Board of Health at Paris, for the use of establishments containing spirits, essences, ether, or any kind of volatile and inflammable substance. It possesses the advantage of having no wire gauze and is filled by a tube. It extinguishes itself when the gas becomes explosive, and is inexpensive. The construction of this lamp is very ingenious, and the Jury regret (it not having been patented) their not being at liberty to describe it.

M. Chuard also exhibits a lamp for chemical purposes, &c.

The Jury awarded the Prize Medal to M. Chuard for his safety-lamp.

BONNET (France, No. 1096) has exhibited an assay furnace and a small assortment of crucibles of white clay. Also a small melting furnace, remarkable for the facility with which it can be taken to pieces and cleaned.

DEYEUX (France, No. 476) has exhibited a large and complete assortment of utensils of the same description.

LEMOLT (France, No. 303) has exhibited a galvanic battery, patented in France and England, in which zinc is combined with a preparation of carbon agglutinated.

KAPELLER and SON (Bavaria, No. 28) have exhibited black-lead crucibles, for melting gold, silver, iron, steel, &c. These crucibles have a high reputation for supporting with security the highest temperatures, such as are requisite for smelting iron, steel, &c., and which is due to the introduction of a fire-proof strengthening substance. They are also very cheap—a crucible to carry 100 marks' weight being sold for four shillings, free from Rotterdam. The Jury award Honourable Mention to these crucibles, &c. (Prize Medal awarded in Class XXVII.)

SEEL, jun. (Prussia, No. 483) has exhibited a remarkably complete and beautiful steam apparatus, fitted for chemical and pharmaceutical purposes, with still, digesting and evaporating vessels, and cases for drying and filtration, at *single* temperatures, in German silver, and which may be considered one of the most complete things of the kind in the Exhibition. A Prize Medal was awarded to Mr. Seel.

ARNOLDI (Prussia, No. 778) has exhibited a good assortment of chemical apparatus, crucibles, evaporating basins, funnels, &c., made of white clay from Thuringen Forest, much resembling, in appearance and quality, our Wedgewood ware for similar uses. In particular may be noticed the great size of some of the vessels, such as a cylindrical one 2 feet in depth and 18 inches in diameter; also a hemispherical basin, 20 inches in diameter.

Gressler (Prussia, No. 854) has exhibited a carbon battery, in which the zinc rods have for their section a rectangular cross to expose a greater surface, and the exterior cylinder is composed of carbon powdered and strongly agglutinated by sugar, it is understood, or other saccharine cement, so composed as to dissolve with extreme slowness.

Dr. Reinsch (Zweibrücken, Bavaria, No. 831) has exhibited a galvanic battery of his own invention, in which a zinc cylinder surrounds one of earthenware full of powdered coke. It is used to exert an electro-magnetic apparatus.

Kinzelbach (Wurtemburg, No. 26) has exhibited a silver hydrometer.

Wolff (Wurtemburg, No. 13) exhibits various chemical apparatus and graduated vessels for measuring fluids. Honourable Mention was awarded by the Jury to Mr. Wolff for his pharmaceutical apparatus for distilling.

Luhme (Prussia, No. 83) has exhibited a rich collection of pharmaceutical apparatus: lamps of different kinds for cooking, calcining, distilling; gasometers constructed in glass, and japanned zinc areometers, mortars, machine for making pills; platina crucibles; an apparatus in platina for preparing hydrofluoric acid; simple apparatus for ascertaining the quantity of sugar in solution by polarized light; glass tubes and various kinds of apparati for use in laboratories made at the Zechlin glass works. For this valuable collection of chemical apparatus the Jury voted a Prize Medal.

Batka (Austria, No. 135) exhibits boxes with chemical tests, lamps, retorts, supporters in wood, alkometers, various kinds of apparati made from Bohemian glass, and a test apparatus for beer, after the design of Professor Steinheil, of Vienna. A Prize Medal was voted to M. Batka.

Brandeis (Austria, No. 133) has an apparatus for the chemical analysis of beer, invented by Professor Balling, of Prague.

Staffel (Russia, No. 148) exhibits an apparatus for assaying precious metals.

This invention of Mr. Staffel is intended to supersede neither the solution by fire, nor the various chemical tests which have been brought to a state of great perfection: it is simply designed for practical purposes, when neither acids nor fire can be made available. The apparatus is constructed on the principle of *specific gravity*, which has been extended to *specific volume*. The great difficulties to be contended with were, 1st, the elasticity of the air; 2ndly, its temperature; 3rdly, capillarity; 4thly, the closing of the apparatus hermetically; and, 5thly, the furnishing a scale for various weights; but after four years of unwearied study and labour Mr. Staffel overcame these difficulties. The apparatus consists of a glass tube, fixed in a brass case, the bottom of which forms a cylinder, which receives *its movement* by means of a screw. An annular dial, furnished with a *hair*, for an indicator, shows the degrees from 0 to 99, and controls the motion of this screw. The degrees, from 100 and upwards, are indicated on a plate, fixed at the side, which plate stands in connection with the dial.

The glass tube is closed hermetically at the top with a glass cover, to which is annexed a capsule, a perpendicular glass cylinder, and two brass bars, serving as a scale.

By the side of the apparatus is a bar, by means of which the dial is brought to zero, and at the same time the fluid in the cylinder is reduced by means of a handle to the normal point. The object to be tested is then weighed by means of weights adapted to the purpose, after which the object is placed in a grate suspended within the fluid, and the capsule carefully closed. The handle is then set in motion and turned, until the weight, previously ascertained, is indicated upon the dial, while the fluid in the perpendicular cylinder will rise to a degree corresponding with the figure on the dial. The figure thus obtained gives the alloy, the remainder the amount of pure metal. For example, if it be required to test an object weighing 24 grains, it will be necessary to stop the dial-hand at 24, and of the fluid in the cylinder, then 8, the result will be

$$24 - 8 = 16,$$

which will give the standard of the gold.

If the gold be alloyed with silver and copper, which will be indicated by the paleness of the colour, it will be necessary to refer to the brass bar for the purpose of showing the alloy. The differential weights of the alloy between gold and copper, and between gold, silver, and copper, are indicated by various scales.

If the object weigh 39 grains, and the cylinder show 11, then the result will be

$$\frac{39 - 11 \times 24}{39 \cdot} = 17 \cdot 23 \text{ proof.}$$

The volume of fine silver or gold is marked . . . F;
The volume of copper, or any other alloy, is marked C;
The volume of specific difference is marked . . . D;
The volume of weight is marked . . . . 1, 2, 3, &c.

If a fusion of 28 F + 11 C is to be made, the figure must be F = C − D, of F + D = C, or 28 F + 11 C = 39 F + 11 D = $\frac{11}{39}$ copper or alloy.

The practical utility of the instrument will chiefly be—

1st. The determining the quantity of gold or silver used in manufacturers' wares from either of these metals, and thereby enabling the employer to ascertain whether the finished article contains the exact amount of metal furnished to the workmen.

2ndly. In ascertaining, if required, the value of a chain, though the gold used in the several links be of a different standard.

3rdly. In previously ascertaining the standard of a fusion, when various sorts of silver, of unequal size and weight, are to be melted together.

4thly. In ascertaining the value of coins with the greatest accuracy and despatch.

Fire Annihilators by Chemical Application.

PHILLIPS (Class V., No. 92) has exhibited a fire annihilator. This is a portable machine for the immediate production of steam, and carbonic acid and other gases, which, being directed upon the burning matter, is designed to check the progress of the flames more speedily than the usual application of water. It is in form cylindrical, and slightly conical; it varies in size from 16 by 8 inches to 24 by 12 inches, and is comparatively inexpensive.

For use, it is charged with a composition of powdered charcoal, nitrate of potass, and gypsum, in the following proportions: powdered charcoal, 20; nitrate of potass, 60; and gypsum, 5. These materials are boiled together in water, and afterwards dried in a stove at the temperature of 100°. The whole is moulded into the form of a brick, down the axis of which penetrates a hollow cavity, for the reception of a bottle, which contains a mixture of chlorate of potassa and sugar, surmounted by a globule of sulphuric acid. The charge so prepared is placed in a cylindrical vessel, perforated in many places, which is itself within another cylindrical vessel, also perforated for the passage of the gases; both these are contained within a double cylindrical receiver, the lower part of which contains a quantity of water. The apparatus is closed by two covers; in the outer of which is an opening for the escape of the vapour. In the centre of the cover is placed a spike, for the purpose of breaking the glass bottle deposited in the cavity of the charge. The spike being forced down breaks this bottle, and the sulphuric acid, falling on the mixture of chlorate of potassa and sugar, causes instantaneous combustion, and spreading over the charge, causes a second ignition at once to take place. The gases thus formed pass through the perforation, and by heating the air in the water chamber, and causing it to expand, forces the water up a tubular passage into the spaces between and around the cylindrical vessels placed each within each; and being thus converted into vapour, mixes with the gases, and escapes by the discharge-tube. The discharge forms a dense cloud, which continues until the charge is consumed and the water quite exhausted.

On Thursday, September 26, several gentlemen of the Jury assembled at Battersea Fields to witness Mr. Phillips' fire annihilator in operation. There were present—Sir John Herschel, Mr. Glaisher, Mr. Bowerbank, and Professor Colladon. A rough wooden house, two stories high, filled with planks of wood, shavings, &c., was set on fire, and the doors and windows fast closed, previously to which a quantity of spirits of turpentine had been poured over the combustibles in the interior, from which, in the course of a few minutes, the flames were seen issuing from the windows, and on the door being burst open presented an unbroken sheet of flame. The fire annihilator was then brought forward, and the vapour directed into the doorway. The effect was almost instantaneous. The great mass of flame was at once extinguished, and at the same moment dense volumes of smoke were seen issuing from the same place. In the course of a few minutes the fire was entirely extinguished, leaving the walls of the house standing, though considerably charred. Ten minutes after (a few lingering traces of fire to the windward being extinguished with wet mops) the Jury entered without inconvenience; the air within being cool and moist. The experiment, which must be considered as a severe test to the powers of the machine, was considered satisfactory in the extreme. Shortly after, a tank, containing a mixture of tar, shavings, and other combustible matters, was ignited, and afterwards extinguished by one of these machines with equal success; the machine being placed to windward, and the gas thus swept over the burning surface, in a state of most violent combustion, instantly annihilating the flame.

The idea which Mr. Phillips has successfully applied to his fire annihilator was suggested to him by witnessing, some years ago, in the Mediterranean Sea, an eruption from an island, thrown up from a depth of 80 fathoms; he observed that, where the vapour formed by the boiling water, and precipitated upon the lava, came in contact with the flame, the latter was instantaneously extinguished.

The fire annihilator, in its action, may be said to resemble that of a pump drawing water, or the condenser of a steam-engine. The vapour which issues from it enters the building in a highly-expansive state, and extinguishes the flame chiefly by the presence of gases adverse to combustion, but partly also, no doubt, by reducing it to a temperature lower than that at which flame can exist. By degrees, the room being full of vapour, the temperature decreases, and the vapour condensing into water, fresh air enters to supply its place, and renders it possible for men to enter, and complete the work of extinction of the embers. The machine is unattended with any practical difficulties in its use: the mixture of steam and gases may be produced within a few seconds after striking the top for the purpose of breaking the little bottle. The vapour itself possesses the advantage of being less destructive to the unconsumed articles with which it comes in contact; and being also a more penetrative medium than water, is better calculated to act simultaneously upon the innumerable particles of gas which combine to produce flame. It is stated to be perfectly innoxious to human life, which, of course, must be understood to mean during that short time, and in that state of admixture with air, in which men have occasion to inhale it.

When we take into consideration the large number of fires which, both by day and night, endanger the life and destroy the property of individuals situated in or near the metropolis, the production of a machine such as that which Mr. Phillips has exhibited, promises to be of very considerable utility. By being provided with one of these, each householder is possessed of an instantaneous means of checking a fire at its commencement, long before any great destruction of life or property could be apprehended. Its advantages on ship-board can scarcely be overestimated, and are most obvious. The Jury, considering it well adapted in its application to the purpose intended, and being perfectly satisfied with its performance in this instance, have awarded Mr. Phillips a Medal.

WEARE (No. 386) has exhibited a fire annihilator, designed, by means of a discharge of gas, to extinguish fire, and prevent the ignition and self-combustion of inflammable matter. As the Jury had no opportunity of examining the machine, or becoming acquainted with its construction, they are not qualified to decide upon its merits.

Meteorological Instruments.

Considering the greatly-increased attention which has been paid within the last few years to meteorological researches upon a systematic plan, a part of which is the using instruments well adapted to the work, it is both surprising and very lamentable to perceive, among the numerous exhibitors of barometers and thermometers, instruments of so ordinary and inefficient a construction, the greater part of them being ill adapted and totally unfit for meteorological observations. In the barometers exhibited, the majority of the makers, in their anxiety to render them elegant and decorative articles of furniture, have paid but little attention to its essentials as a philosophical instrument. Their forms, as exhibited, are various, it is true, not as might be expected with a view to discover that construction likely to give the soundest results, but more, it would appear, to suit the requirements of those who can see in a barometer nothing more useful or important than a piece of household furniture, destined to take its place among the usual appurtenances of a well-furnished hall. This is much to be regretted, the barometer offering, as it does, so wide a field for the exertions of the instrument-maker to fit it for the increasing requirements of the present advancing state of meteorological observation. How disappointing it is to find all their exertions directed to the enshrouding it in a case which, with few exceptions, renders it not only cumbersome and inelegant, but as typifying the apathy of a large class of instrument-makers to the fundamental principles of its construction, to us most offensive. On the score of inelegance of construction, we may, however, except those exhibited by Elliott and Sons (No. 320), which are fairly models of chaste design and excellent wood-carving. It would be well for the purchasers of these decorative and ill-constructed barometers to remember that by their adoption and use of such instruments they forfeit all claim to scientific notice, and they should also remember that to the well informed no instrument can be so pleasing in appearance as that which, from its construction, is well adapted to its work, and likely to lead to good and important results.

Of thermometers we cannot speak more favourably, the greater part of them being furnished with scales of ivory, a material most unsuited to a graduation of any kind; so much so that the mercurial tube attached to an ivory scale cannot rightly be called a thermometer. The bulbs of those exhibited are nearly all too large—a defect which necessarily entails a very slow change of temperature. In self-registering thermometers there is nothing new, and no attempt has been made to improve the working of the instrument, either by the introduction into the maximum thermometer of a piece of enamel as a substitute for the steel index, or by any other means. Very few of the tubes of the thermometers exhibited are sunk in the scale, so that the column of mercury may be in the same plane as the divisions, or the back part of the tube cut away to attain the same object; and, what is still more to be regretted, very few thermometers in the English portion are graduated on their stems, a method superior to any for insuring delicacy of graduation and correct readings. These remarks do not apply to the foreign portion of the Exhibition: the exhibitors it includes, however, are few in number; but the instruments generally are pretty good.

No branch of physical science has suffered more than meteorology by the use of bad instruments. Many journals, after years of patient daily labour, have necessarily been laid on one side as useless, owing to the imperfections of the instruments used. To judge from those exhibited, it would appear that as little attention is paid now to the construction of meteorological instruments in London, except by a few makers, as a few years ago, before the commencement of the systematic researches in meteorology at present being carried on by very many gentlemen throughout the country.

It is to be hoped that one of the good results of the Exhibition will be the calling into existence a better class of instruments generally, when not only shall be improved those necessary to physical research, but those also which are in general use by the public. That thermometer is the best whose bulb is small, whose divisions are cut on the stem itself, or engraved on well-seasoned box-wood, or on metal. That barometer is the best which is made of brass throughout, and the mercury of which has been boiled in its tube; there should be no plunger, no need of capacity correction; and the most simple means should be adopted for measuring accurately the distances between the surface of the mercury in the cistern and that in the tube, a measurement best attained by means of an ivory point, terminating a brass scale.

The best exhibitor of thermometers in the Exhibition is FASTRÉ (France, No. 511). All the instruments exhibited by him are distinguished by delicacy, and are possessed of the essentials of first-rate instruments. The best exhibitors of thermometers in the British portion of the Exhibition are NEGRETTI and ZAMBRA (No. 160), whose instruments seem to have been made with great care, the divisions being good, and mostly cut on the stems of the thermometers themselves. In appearance there is but little difference between those exhibited by Negretti and Zambra and those by Fastré. The accuracy of division was not examined in either case.*

We now proceed to speak in detail of the instruments exhibited.

Self-Registering Meteorological Apparatus.

DOLLOND (No. 145) has exhibited a self-registering meteorological instrument, which he has called an Atmospheric Recorder.

This instrument registers simultaneously for any period of time, according to the length of the paper used, the varying pressure of the atmosphere, the changes of temperature and evaporation, the variations in the electrical state of the atmosphere, the fall of rain, the amount of water evaporated from a surface of water, and the force and direction of the wind.

The apparatus is composed of a frame 2 feet by 3 feet 6 inches, and is firmly supported upon four pillars, the sides being strongly braced together. At the distance of 10 inches from either end of the frame, a roller, 1 foot in circumference, is placed. That near the south end is moved by clockwork, whilst the other acts as a reservoir for the paper; a third, of the same dimensions, is placed near the clock or driving roller, and so arranged as to press upon it equally throughout its length for the purpose of keeping the paper in contact with the driving roller.

A strong bar is placed near the north end of the frame, upon which the fulcrums of several indicators, about a foot in length, are placed. Those for registering the variations of the barometer, thermometer, and hygrometer, have spring points at their ends; and those for the registration of the electrical changes, the fall of rain, evaporation, and the force and direction of the wind, have pointed pencils. The former are connected with a falling lever, and strike the paper once in every half hour, whilst the latter continuously mark the paper. Near the place of registration each element has its own scale. The indicators are continued somewhat beyond the fulcrums, and are thus connected with the various changes of the atmosphere to be recorded. Between each element on the paper a set of lines is drawn, which form zeros or base-lines for the estimate of each. They also give a means of correcting any error caused by the hygrometric or other changes

* To examine a thermometer carefully, and determine its index errors at every part of the scale, is very troublesome, and occupies a great many hours; yet every thermometer used for meteorological purposes should be thus examined.

of the paper; on either side of the frame is a marker, which registers the time simultaneously at every half-hour.

The barometer used is on the siphon principle, in the shorter leg of which is placed a float, so adjusted as to leave sufficient weight to follow the mercury. The registered scale trebles the actual changes. The apparatus for the temperature consists of ten bent mercurial thermometers, suspended upon a delicate balance. The hygrometer consists of a slip of mahogany cut across the grain, which was divided as follows: being suspended from its upper end, in a cylinder filled with water, a weight of 2 lbs. was attached to its lower extremity, until it was found, by repeated examination, to be completely saturated, and no longer to increase in length. Its whole length was then referred to an accurate scale. The slip of mahogany was then placed beside the pipe of a stove suspended and weighted as before, until its shortest length was obtained. The difference of the two results being carefully taken, the scale was formed accordingly. In its use it is suspended and weighted as before, in a tube placed outside the observatory, protected from the sun and rain, and has free power to act upon the indicator.

The electrometer is constructed as follows: a well-insulated conductor is placed upon the highest convenient place, from which a wire is brought down to an insulator on the top of the observatory, and from thence to a standard, passing through another insulator to a metal disc, between which and a spring a moveable disc is attached to a glass or insulating arm, in connection with the registering pencil.

The electricity, in the first instance, is collected by means of points. There is a wire, connected with the earth, by which means, any excess of electricity is discharged.

The rain-gauge is placed on the top of the observatory, its receiving surface being 1 foot square. The rain is conducted by a pipe into a receiver inside the observatory, and situated under the registering apparatus. An air-float is placed inside the receiver and connected with a set of inclined planes, each of which is equal to a fall of rain 1 inch in depth. These inclined planes as they pass upwards, being in connection with the indicating pencil, register the fall of rain.

The evaporating dish is an open cube of 1 foot square, covered with a plate of glass at such an angle as to prevent rain falling into it, yet allowing the air to act freely upon the surface of the water.

The direction of the wind is shown by an indicating pencil in connection with a vane. The force of the wind is shown by a surface of 1 foot square, being kept in opposition to the direction of the wind by a vane, whose motion is nearly free from friction, every part being counterpoised. On the action of the wind upon the pressure plate, a combination of suspended weights is raised by a chain passing over a pulley in a line with the direction of the wind, and well protected from the weather. The suspended weights are in connection with an inclined lever and indicating pencil. The scale has been determined by experiment. *A Council Medal was awarded to Mr. Dollond.*

BROOKE (No. 144) exhibits photographic apparatus for the self-registration of the dry and wet bulb thermometers.* It consists of two mercurial thermometers, with very long bulbs; one of them is covered with muslin, which is kept moistened

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* The principle is the same as that described in Magnetical Instruments, pp. 610, 611.

by the capillary action of floss silk, or lamp wick, connected with three cisterns of water.* On either side of the thermometers, and placed near them, is a lamp, the light of which, condensed by a cylindrical lens whose axis is vertical, falls upon the thermometer stems, and passing through that portion which is above the mercury, affects the paper. As the cylinder revolves, a broad sheet of photographic trace is left, whose breadth varies with the varying height of the mercury in the tube. The boundary of light and darkness thus indicates the height of the mercury in the stem of the thermometer. To know the temperature corresponding to this boundary, fine wires are placed across the thermometer-tube, to prevent the photogenic action of light, and thus transfer sufficient indications of the actual reading of the thermometer. Mr. Brooke also exhibits similar apparatus for the variations of the reading of the barometer. (See Illustrated Catalogue.)

NEWMAN (No. 674) exhibits a self-registering anemometer and rain-gauge. It consists of a vertical cylinder, actuated by clockwork, and furnished with paper for the consumption of a month.

Barometers.

GRIFFITH (No. 331) exhibits a barometer of a new construction, giving the observer the power at all times of securing a vacuum above the mercury. The instrument consists of a tube for the column of mercury, with a crook on the top, and bent at the lower part, a joint with a trap placed near the middle of the tube, a stopcock, and a stretcher to close the open part of the glass tube when necessary; a brass bar carrying two cylinders at the distance of 29,772 inches, and moved up and down by means of a steel screw, with 25 threads to an inch, moveable in a matrix by means of a milled head. The bar carries a pointer for reading to hundredths of inches, and there is suitable apparatus to read to one-thousandth of an inch.

The purpose of the crook on the top is to trap all the air which may be above the column, and thus to ensure a good vacuum.

Mr. Griffith says that no boiling of the mercury is necessary. The instrument, though not tried, and not of very careful workmanship, was considered by the Jury good in principle, and an attempt out of the beaten track to improve the instrument. A Council Medal was awarded.

NEWMAN (No. 674) exhibits his well-known standard barometer, which is made so as to require as few corrections as possible. The graduated scale which measures the height of the mercury is made of brass, and to it is affixed a brass rod, passing down the inside of one of the upright supports, and terminating in a conical point of ivory: this point in observation is made just to touch the surface of the mercury in the cistern, and the contact is easily seen by the reflected and actual point appearing to meet each other. The rod and scale are made to slide up and down by means of an endless screw and wheel. The scale is divided to 0·05 inch, and the vernier, which only moves by a slow-motion screw, subdivides the scale to 0·002 inch.

At the bottom of the instrument are three screws, turning in the fixed part of the support, and acting on the piece in which the lower pivot of the barometer

* One large cistern will be found to act better.

frame turns for adjustment to verticality. The bore of the tube is between 0·5 0·6 of an inch in diameter.

Mr. Newman observes that he has always found tubes boiled under atmospheric pressure to be foul, and that many barometers made with large tubes not boiled look well for a time, but that ultimately air bubbles are seen to rise to the top and depress the column. These difficulties were to be overcome before filling the tube successfully, the bore of which measured from 0·5 to 0·6 of an inch in diameter. Mr. Newman has adopted the method of filling tubes in vacuo, and boiling them under diminished pressure, at a temperature which obviates all oxidation of the mercury.

ORCHARD (No. 161) has exhibited a standard barometer very similar in construction and workmanship to that of Newman; it has, however, in addition a thermometer, placed in front of it, with a bulb of the same diameter as the tube, and there can be no doubt that the temperature of the two equal bulks of mercury will be the same.

VIDI (No. 326) exhibits an aneroid barometer of the usual construction. This beautiful instrument, lately invented by M. Vidi, was rewarded by a Council Medal.

NEGRETTI and ZAMBRA (No. 160) exhibit a barometer arranged to register the highest and lowest readings. It is a siphon barometer, to the longer leg of which, at the distance of 8 inches from the top, is joined a bent glass tube, carried up for 6 inches parallel to the principal tube, and joining it at 2 inches from the top. The mercury flows freely in and out of this tube, and maintains the same level as that in the larger tube. In this bent tube is placed a small piece of steel, which is kept in position by fine glass springs: as the mercury rises this piece of steel is pushed up, and remains stationary. The lowest readings are indicated by a similar steel index in the shorter leg.

Messrs. Negretti and Zambra also exhibit a barometer with an air-trap glass cistern, to be read off by means of a sliding scale, adjustable to the surface of the mercury by a fine ivory point. The tube and cistern are blown together, and at intermediate junctures are three points, and three small tubes or traps, communicating with each other to prevent the admission of air. This instrument is constructed entirely of glass. A folding barometer is also exhibited, consisting of a tube with a steel stopcock in the centre, which, when folded up, carries with it the two valves of the tube with which it is connected.

YEATES (No. 332) exhibits a barometer, furnished with a brass scale, terminating in an ivory point, and moveable by a screw. The cistern is composed of plate-glass and iron.

Mr. Yeates exhibits also a barometer, furnished with a registering apparatus, which consists of a revolving cylinder four inches in length, around which is paper ruled into thirty-one vertical portions, horizontally into tenths of inches, and numbered from 27 inches to 31 inches. To the receiver a pencil is attached for marking the paper. The ivory point is adjusted to the surface of the mercury by means of a plunger. Mr. Yeates also exhibits a third barometer, furnished with an ivory point, adjusted by a screw acting upon a leather plug attached to the bottom of the cistern. In these three barometers a ready means is furnished of cleansing the surface of the mercury in the cistern, by the withdrawal of a screw-plug, placed in the cistern near the surface of the mercury.

SOMALVICO (No. 681 A) exhibits a mountain barometer, two upright barometers, three ornamental wheel barometers, &c.

HALL (No. 60) exhibits a meteorological clock, to which is attached a barometer and thermometer kept vibrating by the clock connection, the number of vibrations in a certain time differing according to the variation of temperature in the one case, and of pressure of the air in the other; the number of vibrations is registered, and from them both the reading of the barometer and thermometer are known.

TREMLETT (No. 163) has exhibited a marine barometer in a metal frame, with thermometer, enamelled scales and springs to check oscillation.

ELLIOTT and SONS (No. 320) exhibit barometers carved in walnut-wood, the design representing the four Seasons; circular carved wood barometers similarly ornamented; Gothic carved barometers, and two mounted in ebony and gold. It is stated that the mercury in the tubes of all these instruments has been boiled.

BURSILL (No. 673) has exhibited a compensatory cistern barometer, in which, by a self-acting contrivance, the mercury is always preserved upon the same level within the cistern, uninfluenced by alteration of temperature or any change in the column of mercury itself.

BROWN (No. 676 A) exhibits a barometer in appearance similar to a water-barometer: it contains two immiscible liquids of nearly equal specific gravities; and their point of meeting, which may be placed at any part of the scale, is indicated by one liquid being coloured. The scale of the instrument, which is arbitrary, is 7½ feet to an inch of mercury.

Mr. Brown also exhibits two barometers at an exceedingly low price. The readings of a similar barometer were taken for two months commencing from July 15, simultaneously with those of a standard barometer, and was found to act admirably. Before reading it was always found necessary to incline the instrument until the mercury filled the upper portion of the tube: it afterwards descended to its proper level, though the rise at all times took place less freely on account of the smallness of the tube. These barometers are the cheapest in the Exhibition, and are better than any of the ordinary barometers exhibited.

BENNETT (No. 1) exhibits barometers of an ordinary construction.

DIXEY (No. 271) has exhibited a carved oak barometer, and an ordinary barometer.

BAKER (No. 616) has exhibited two barometers, one of which is that invented by Mr. Brown.

WATKINS and HILL (No. 659) have exhibited barometers of various ordinary kinds, and Professor Potter's aerometric balance.

GREY and KEEN (No. 138) have exhibited wheel barometers mounted according to various designs.

ABRAHAM (No. 140) has exhibited a barometer, designed to show without adjustment, the reading of the barometer. The scale is suspended over a pulley, by means of a counterpoise, the lower end of the scale being connected to a float in the shorter leg of the siphon.

A. H. ROSS (No. 157) has exhibited a self-compensating barometer.

PIZZALA (No. 162) has exhibited a wheel barometer, constructed with a rack-work motion. The case is elaborately carved in walnut-wood.

Grimoldi (No. 159) has exhibited a pediment barometer, fitted up in a carved gilt frame.

Bourdon (France, No. 1108) has exhibited several barometers of an original construction. They consist of an elastic flattened tube of metal, exhausted completely of air, and bent very nearly in the form of a circle: they are in this state possessed of the property of expanding; a further separation of the ends being effected when the atmospheric pressure is diminished, a contrary or contracting effect taking place when the pressure increases. A lever is attached to the end of the tube by suitable mechanism, and connected to an index or hand, which traverses a divided dial-plate.

The dial-plate is graduated by placing the instrument with a standard barometer within the receiver of an air-pump, and the points of coincidence determined by varying the pressure. These instruments are applicable for measuring the pressure of the atmosphere, gas, &c., to a range exceeding 500 lbs. on the square inch. They are well adapted for application to steam-engines, &c. A Council Medal was awarded to M. Bourdon.

Galy Cazalat (No. 1239, France) has exhibited a manometer. The tension of steam is measured by the number of atmospheres to which its pressure is equivalent, consequently by the number of inches of mercury which it will support in a tube by pressure on the surface of a reservoir into which the tube is plunged. The utility of a mercurial gauge is limited in practice by the length of tube capable of being applied, which, if of glass, cannot be safely extended, and if of iron, is very inconvenient, to say nothing of the difficulty of reading. The invention of Mr. Galy Cazalat is in effect equivalent to increasing in any given ratio the specific gravity of the mercurial column, supported so as to enable a column of any convenient length to counterbalance a pressure, however great. The steam acts only on the sectional area of the rod of a piston, the plunger of which, of much greater sectional area, presses on and so sustains, in the other leg of the inverted siphon, into which it plunges, a mercurial column of sectional area equal to its own. A Prize Medal was awarded to Mr. Galy Cazalat.

Ericsson (United States, No. 146) has exhibited an alarm barometer. This instrument is intended chiefly for use on ship-board, and is to be placed in the vicinity of the helmsman, being so constructed that, when the mercury sinks below a certain reading, a hammer is made to strike a gong. The helmsman by this means receives notice of the probable approach of rough weather, and time is afforded for the necessary precautions of taking in sails, &c.

The tube is similar to that of the common barometer, and is much enlarged at the upper end; the lower extremity terminates in a cup, which contains mercury, and is attached to a lever, weighted at one end. By means of the enlargement of the tube, a slight decrease in the reading of the barometer causes a considerable discharge of mercury into the cup, the balance of which is disturbed. This disengages a hammer, which, impelled by a spring, strikes a gong with considerable force. The weight which balances the cup is adjustable upon the lever, and may be so set that notice shall be given of any required reading of the barometer. The lever is marked with divisions, corresponding to those on the scale, for the purpose of adjustment.

Thermometers.

SIMMS (No. 741) exhibits two standard thermometers, constructed by the Rev. R. Sheepshanks, who, during the last two or three years, has been more or less engaged in improving these instruments. The divisions are engraved on the stems. The zeros of these instruments, as determined by Mr. Sheepshanks, will be used by Mr. Glaisher in all future observations, and he believes the two instruments, exhibited by Mr. Simms, to be the most correct in the country.

NEGRETTI and ZAMBRA (No. 160A) exhibit a standard thermometer, which seems to be good; several very delicate thermometers, with pea bulbs; a delicate dry and wet bulb thermometer; a Daniell's hygrometer; two Regnault's hygrometers, one furnished with black glass cups, instead of silver, designed to avoid oxidation; some thermometers beautifully made, and graduated on their own stems; a dry and wet bulb, with two identical stems close to each other, and united; this form of instrument is useless for practical purposes, but is a masterpiece of tube-blowing; several self-registering thermometers, both of Rutherford's and Sixe's form, &c.

These are the only Exhibitors in the British portion who have sent thermometers with their stems graduated, the only safe instruments for delicate experiments.

A Prize Medal was awarded for the beautiful work shown by these artists.

NEWMAN (No. 674) exhibits a standard thermometer, the bore of which is stated to be a perfect cylinder, having been examined by the late Captain Kater and Professor Daniell, as well as by Colonel Sabine. Its scale is divided into half degrees; that part of the glass tube which is near the scale is ground flat, and polished, so that the column of mercury is very nearly in the same plane as the scale, by which means the error of reading, so far as parallax is concerned, is avoided. Also, a maximum register thermometer, with a small piece of enamel inserted between the index and the mercury; a minimum and maximum register thermometer, with black bulbs; a Daniell's hygrometer; dry and wet bulb thermo meters; a Lind's wind-gauge; and rain-gauges of different kinds.

PHILIPS (No. 411) exhibits a maximum thermometer, with a bubble of air, which, by separating a portion of the mercury, causes it to act as the index; an air-barometer for coal-pits; and a new electrophorus and cover, to work without making contact by the hand.

WATKINS and HILL (No. 659) exhibit a dry and wet bulb thermometer, and other thermometers of an ordinary kind.

HARRIS and SON (No. 149) have exhibited a self-registering thermometer.

ELLIOTT and SONS (No. 320) exhibit various ornamented thermometers, and some intended for the pocket.

BENNETT (No. 1) has exhibited many thermometers; they are for the most part furnished with ivory scales; the bulbs of those furnished with box-wood scales are too large.

DIXEY (No. 271) has exhibited several self-registering thermometers.

BAKER (No. 396) has exhibited a thermometer for agricultural purposes.

FASTRÉ (France, No. 501) exhibits probably the best series of delicate and accurate thermometers in the Exhibition; they are distinguished by being nearly all engraved on thin glass stems, and include exceedingly delicate dry and wet bulb thermometers, Regnault's hygrometer, &c. M. Fastré deserves high praise for the production of these beautiful instruments, which the Jury consider worthy of a Prize Medal.

Luhme (Prussia, No. 83). Good thermometers; divisions on glass, and some on paper.

Zerack (Austria, No. 134) has exhibited thermometers graduated on glass, for immersion in acids.

Jürgensens and Sons (Denmark, No. 17) exhibit two metallic thermometers, of a circular form, so arranged to show the temperature at the time of observation, as well as the maximum and minimum temperatures since the previous inspection. A Prize Medal was awarded to Messrs. Jürgensens and Sons.

Anemometers.

Philips (No. 411) exhibits an anemometer, designed for coal-pits and hospitals, consisting of a semicircle of card-board, graduated on its edge, and mounted on an axis passing through the diameter of the circle of which the card is the half.

De Hennault (Belgium, No. 183) exhibits a small travelling anemometer, extremely well made, of a simple construction, and furnished with a series of fans, which, by a simple and effective contrivance, may be stopped or set in action almost momentarily. It is intended chiefly to determine the horizontal velocity of the air in a given time. To this exhibitor Honourable Mention was awarded.

Rain-Gauges.

Philips (No. 411) exhibits a rain-gauge, open at the top and four sides, prepared to show not only the fall of rain received on a horizontal surface, but also, by a simple calculation, to ascertain the inclination of the path of the drops and the direction of the rain. The Jury have awarded Honourable Mention to Mr. Philips.

Watkins and Hill (No. 659) exhibit Crossley's self-registering rain-gauge.

Baker (No. 396) has exhibited a rain-gauge.

Pyrometers.

Ericsson (United States, No. 146) has exhibited a pyrometer, an instrument for measuring temperatures from the freezing point of water to the melting point of iron, as indicated by the tension of a permanent volume of air or azote, which is measured by the reading of a column of mercury under a vacuum. The instrument is designed to meet the requirements of the artizan in all works which involve the application of great heat, and are dependent for success upon an evenly-regulated temperature. In the formation of the scale, 32° and 212 have been respectively taken for the points of freezing and boiling water.

The instrument is composed of the following parts:—

A chamber containing mercury, with a flexible bottom, composed of a steel spring, or India-rubber, held between steel plates, which may be raised or lowered by means of a screw. Into this chamber a glass tube filled with mercury is plunged to within one-sixteenth of an inch of the base.

Into the mercurial cistern a short glass tube is inserted, connected with a platina bulb by a small passage, the base of which is nearly filled by a silver wire, and a stopcock. A coupling-joint is affixed to the bulb so that it may be removed at pleasure. The top and sides of the mercurial chamber are surrounded by a cistern for the reception of pounded ice, the whole being encircled by double plates of iron, to be filled with clay or some other non-conducting substance, for the purpose of shielding and supporting the instrument. The screen itself is supported upon a base-plate. Two scales form an important feature in the arrangement of this pyrometer, graduated for reading off the height of the mercury in the tube, which reading is determined by the temperature of the medium in the platina bulb.

The graduation of the smaller of these scales reaches only to 700°, but that of the larger is extended to include the melting point of iron. A spirit-level for placing the instrument in a vertical position completes the adjustments.

It is to be remembered, that the graduation of the scale is independent of any imperfection in the bore of the tube, and is not affected by the expansion of the bore from heat, the volume for measuring which being permanent and not expanding, affords greater accuracy in the readings at high temperatures.

The pyrometer comes into action where the thermometer ceases to be effective, the air or azote in the bulb of the former enabling it to remain unchanged under extreme variations of temperature, whilst the latter explodes on being thrust into an ordinary flue or vessel of over-heated lead.

WURM, Austria (No. 137), has exhibited a pyrometer. The instrument is composed of a strong and massive frame of iron with a handle, across which is stretched a moderately-strong platina wire, connected with an index in the handle, so arranged that the wire (being always kept in a state of tension by a spring or otherwise), when relaxed by expansion, shifts and marks the amount of extension.

The whole frame being introduced into a furnace or oven, the wire acquires instantly the temperature; the massive frame much more slowly. Relative expansion of the wire therefore takes place, and when this has attained its maximum the index is read off.

The instrument exhibited is adapted to ovens, &c., and is of considerable dimensions.

Tide-Gauges.

HEWITSON (No. 152) exhibits a self-acting and self-registering tide-gauge, every part of which exhibits good workmanship, and an endeavour to reduce friction or grip to a very small quantity. The teeth of the wheels are carefully made, so that should the rise or fall of the tide amount to the fraction of an inch only, a simultaneous movement of the whole machine follows to that extent. It is furnished with a brass cylinder, the axes of which are of bell-metal, revolving in Y's. The traversing bar carrying the registering pencil, moves on steel friction rollers, concealed in the capitals of the brass supporting pillars. In connection with it is an astronomical clock, which vibrates seconds, and needs winding once in 16 days only, so that somewhat more than a chart of tidal curves, extending from new moon to full moon, or *vice versâ*, can be registered without any attention being required.

The instrument is also furnished with a system of wheels, by means of which the depth of water is shown on a circular dial; that placed at the mouth of the Tyne is illuminated at night, and can be seen at a great distance at all times.

The instrument is elegant in appearance, and seems to be perfect in its action, and is the only one which shows time and tide by separate dials. A Prize Medal was awarded to Mr. Hewitson.

Newman (No. 143) has exhibited a self-registering tide-gauge. This instrument consists of a metal cylinder 30 inches in length and 8 inches in diameter, moved by a clock, and performing one revolution in 24 hours. A pencil moved by a float is suspended by an endless chain, and maintains always the same buoyancy. The pencil attached to the chain is carried over two cylinders, one of which contains a spiral spring, and is so contrived, that the marking of the change of tide is immediate. On the face of the clock is shown the height of the tide at the time of observation. It also registers the highest and lowest for the day. The papers require replacing every fortnight, and the pencils used are metallic.

The chain consists of a given number of links, the ends of which are not soldered together, which in its progress loops over the spikes in the barrel: this method will do well for a time; but as the links cannot keep all of the same length, it is probable that some will not catch, but slip past, and cause error in the register.

Acoustics.

Heeps (No. 615) exhibits a pulpit, to the reading-desk of which is attached a receptacle for collecting sound, to which a gutta-percha tubing is connected, intended to be carried under the floor, or otherwise, to the pew of the deaf person; the terminal of the tube, which is intended to be applied to the ear, is of ivory.

Rein (No. 629) has exhibited several instruments for acoustic purposes; one of these may be worn without being seen, is adapted to the shape of the ear, and requires no spring. The power is great in proportion to its small size, the entire length of tube being eight inches.

Another acoustic contrivance, which may be worn as a lady's head-dress, without being seen.

Also a new promoter of hearing. The great fault in instruments of this class has hitherto been the concentration of the sound in one ear only; so that, whilst the sound was much increased in loudness, it remained, if possible, still more confused and indistinct. To obviate this inconvenience, Mr. Rein designed this contrivance, which is to be worn on the head and is adapted to both ears: by means of it the faulty ear is called into equal action with the healthy one. When worn by ladies, it may be quite concealed by the hair.

An acoustic chair. This is so constructed that its power by reflection is doubled to either ear, and may be used at pleasure for one or both ears. In the latter case the power is fourfold. The chair is rendered acoustic by the arms being made hollow, and terminated by a design suitable to the free admission of sound, which is conducted to the ears of its occupant, by two small tubes, projecting from the inner side of the back of the chair.

An acoustic vase, designed by its construction to collect the sound from all parts of the room. The vase being placed on a small table, the attachment of the tube is skilfully concealed beneath the table through which it is inserted; contrary to other contrivances for the same purpose, it is not trumpet-shaped, and in its appearance does not resemble an acoustic instrument.

All acoustic instruments hitherto made, partake more or less of the trumpet form; and all agree in one respect, viz., that the mouth or orifice for the reception of sound, is bounded by a line, generally circular, every point of which is in one plane; and, therefore, it is necessary that the voice of the speaker should be directed as nearly as possible at right angles to this plane. Some instruments have been made consisting of a large metallic receptacle for the sound, with a long flexible tube attached to them; but they are very unsightly objects. The vase above described differs from these in the following particulars:—

1st. That the orifice for the collection of sounds is arranged on a circular plan, so that when the instrument is placed on a table in the centre of a room, the deaf person can hear speakers in any direction with distinctness proportionate to his degree of deafness, or the tone of voice used by the speaker.

2nd. That it has not the appearance of being an acoustic instrument.

3rd. That it may be used as a flower vase. It is of course furnished with a flexible tube for the purpose of conveying the sound from the vase to the ear.

Mr. Rein has exhibited more than one design of the acoustic vase, several acoustic bells, also an acoustic walking-stick, which may be applied to either ear, without being recognized as an acoustic instrument.

Several portable telescopes, adapted to various degrees of deafness.

An acoustic instrument, or "Social Companion," to enable any number of persons to converse with one who is deaf, and requiring no change of place.

A conical and flexible whispering tube, so constructed that extremely deaf persons can distinctly hear and hold conversation even when spoken to in a low tone of voice.

A whispering tube, and ear-caps or reflectors, which last may be worn without a spring.

WATKINS and HILL exhibit a syrene; an instrument used in acoustics for demonstrating the production of a musical sound by a succession of musical impulses. The invention of M. Cagniart De la Tour.

Planimeters.

SANG (No. 338) has exhibited a planimeter. The peculiarity of the construction consists in the product of the ordinating lines being given by the motion of a disc over the surface of a cone, instead of over a plane, by which means, the motions representing both the ordinates may be taken directly from the motion of the tracing point. In the Tuscan instrument the motion which represents one of the ordinates is conveyed through a rack and pinion, and in those of Swiss and German construction, through a hand and pulley. The arrangement of Mr. Sang is designed to obviate the shake necessarily caused by the teeth of the rack, and by the elasticity of the band of the pulley.

The parallelism of the instrument is trusted entirely to the simple rolling of two heavy wheels over the paper. This is rendered more certain in the foreign instruments by the rollers working in guides as on a railway. All, however, appear free from any tendency to divergence in this respect.

Mr. Sang's instrument possesses a practical advantage in the readiness with which it may be placed at once on a drawing of any size.

The error contained in the results given by instruments of this class generally arises from the shaking or elasticity of the parts which connect the index with the tracer. This error in practice may be easily corrected by measuring the figure twice; at one time placing it so that the shortest breadth is represented by one of the motions, and at another, so that the longest breadth is represented by the same motion. The average of the two results will be very nearly the truth. The Jury considered Mr. Sang as well deserving Honourable Mention.

GONELLA (Tuscany, 27) has exhibited a planimeter. All, or very nearly all, the planimeters, of which the Exhibition contains several, turn upon the mechanical integration of the differential expression for the area of a curve traced on a plane surface, and are most readily conceived on that old and now almost forgotten view of the differential calculus, which regarded the differential of a magnitude as a measure of the velocity of its increase at any instant. Suppose a straight line to be carried with a uniform motion along the base line (or abscissa as it is termed), of any curvilinear area, remaining always parallel to itself and perpendicular to the base line; and that, during this motion, a moveable point in the line so carried is kept always on the circumference or boundary line of the area. Then it is clear that the *velocity of increase of the area* will be proportional to, and therefore measured by the length of, the ordinate, or point of the moveable line, included between the base line and describing point.

Suppose, again, that a circular disc or wheel can be made to revolve with an angular velocity, always proportionate to the same ordinate. Then will the total angle of revolution described by it from zero increase by similar increments with the curvilinear area, and consequently be always proportionate to and a measure of that area. The area, therefore, may be in effect *read off* upon its circumference by any method which shall keep account of the number of revolutions and parts of a revolution made by this wheel, which may be called the *integrating wheel, disc, or roller.*

If a circular disc be made to roll (whether by rack-work or friction) upon a line parallel to that on which its centre moves uniformly, its angular motion will be uniform. Supposing then a racket bar, parallel to the abscissa and incapable of motion in the direction of its length, to work into a toothed wheel on the axis of such a disc, that disc will (however carried) revolve uniformly when the motion of its centre parallel to its abscissa is uniform. To convert this uniform angular motion into one proportional to the varying ordinate is, therefore, the problem of planimeters so conceived.

If the circumference of two circles, *whether in the* same or in different planes, be so connected, either by teeth, as in ordinary wheel-work, or by mutual friction and adhesion, their angular velocities are inversely as their radii; so that if the radius of one of them be constant, its angular velocity will be directly as the radius of the other. Any disposition of the parts of a mechanism then, which shall secure the condition, that a roller or rolling disc shall be carried round on its centre by contact with a uniformly-revolving circle of a radius, always equal to the length of the variable ordinate, contains the solution of the problem. The uniformly-revolving disc may be horizontal (that is parallel to the surface of the area to be measured), and the integrating roller at right angles to its plane, having its axis horizontal and parallel to the ordinate as directed to the centre of the disc. This is the construction adopted by Gonella and Gaspar Wettli, or it may be perpendicular to the horizon, being no other than the transverse section of a cone whose vertex lies in the abscissa of the curve, and the radius of which section is therefore proportional to the distance from the vertex, or to the ordinate. This is the construction adopted by Sang (338); but it is only justice to Mr. Gonella to state that this construction is expressly indicated and figured in his original Memoir on the Planimeter, which carries the date 11th June 1827, in which there will be found a full account of Mr. Gonella's instrument, and a very elaborate (though unnecessarily complicated) exposition of its theory, and to which we therefore refer for the particulars.*

A very great saving in the expenses of computation in the reduction of local surveys, to give the areas of districts, parishes, estates, and fields, as laid down in maps, has been found to result from the use of these instruments, where indications are sufficient for all practical uses.† A Council Medal was awarded to Mr. Gonella.

LAUR (France, No. 567) has exhibited a planimeter, in which the area of a plane, supposed to consist of triangles, is first reduced, by geographical construction, to any right-angled triangle. On a rectangle of either gelatine paper or transparent horn are engraved a series of hyperbolas, such that the product of the ordinate and abscissa contained for each, shall change from hyperbola to hyperbola by a constant increment. The extremity of one side of the triangle then being made to coincide with the common centre of all the hyperbolas, and that side with the asymptote, the opposite angle will of necessity fall on one or between two adjacent ones of the hyperbolas, and its area (or its double) will be therefore expressed by the ordinal number of the hyperbola, or the number of the lowest *plus* or proportional part for the distance between that and the angle, as compared with the interval between the two consecutive curves.

This instrument, termed an "olarithme," is intended for the use of persons engaged in geodetical operations, and it offers a simple and ready means of measuring the surface of any portion of a plane. The Jury awarded Honourable Mention.

WETTLI (Switzerland, 84) exhibits a planimeter, for measuring the area of any plane figure, by the simple operation of drawing a tracing-point round its periphery, the area being indicated by the divisions of a circle, which is fixed.

The disc is of glass, covered with paper, and receives the movement of rotation by suitable and simple mechanism. The results obtained by this instrument have been found to be correct within 1-1000th part of the area. The Jury awarded a Prize Medal.

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* Opuscoli Matematici, &c. &c. &c. Di Tito Gonella Professore di Matematiche Nell' I. E. R. Accademia Delle Belle Arti di Firenze. Firenze 1841.

† Tracing with a pen dipped in dilute sulphuric acid on paper of a moderate and uniform thickness by the aid of transmitted light, and weighing the portion *cut out* by the corrosive action of the acid on exposure to heat, will enable any one to extemporise a planimeter, following the most intricate details of outline, and giving the total area with a very considerable approximation.—J. F. W. H.

Ausfeld, Gotha (Prussia, No. 704) exhibits a planimeter, consisting chiefly of a small roller, moving upon a horizontal disc. The instrument is well conceived and tolerably well carried out. The Jury awarded Honourable Mention.

Dynamometers.

Taurines (France, No. 386) has exhibited a dynamometer, adapted for the measurement of very great powers. The driving power, instead of acting at right angles to the spring to be bent, acts lengthways, or rather in the direction of the extreme tangent of a circular arc of nearly 120°, into which the spring is formed, one end being pressed on by the driving power, the other inserted at right angles into a strong radial bar emanating from the axle to be driven. Two such springs nearly complete the circle, and by compression are rendered more convex, and their opposite points made to recede. These opposite points are connected two and two by two other oblique-acting springs, which magnify the motion communicated to their extremities, and through the medium of a third pair, connecting their opposite points, ultimately push along the axis. A cylinder of brass serves as an index, and reads off a scale indicative intrinsically of the distance to which the cylinder is carried out from its zero point, but of which the graduation is so executed as to indicate the power necessary to drive it to that distance: this graduation is executed by trial. The instrument is useful only for heavy engine work. A Council Medal was awarded to Mr. Taurines.

Clair (France, No. 1151) has exhibited a dynamometer in which the driving-wheel of any axle, when thrown into gear with the moving power, is brought not at once to lock into connection with the axle, but to press at once on a strong straight steel spring standing at right angles to the axis. The degree of flexure of this spring is read off by an index, to the measure of the force required to overcome the resistance, and drive the axle round. It is therefore applicable only to moderate powers, such as may be measured by a spring of reasonable strength, bent by direct action. It can be used either horizontally or vertically. By the application of a train of wheel-work, the movement is made self-registering in every instance, and the work done, with the variations from instant to instant of the driving power required to overcome the resistance, is registered.

M. Clair has also exhibited the model of a locomotive fire-engine; a vertical section is also exhibited upon a large scale.

De Burg (Austria, No. 130) has exhibited a dynamograph. This is an instrument not unlike Regnier's, with the addition of a piece of clockwork, regulated by a fan, which can be set in motion or stopped at pleasure; it carries a pencil along the index of the instrument, recording at any moment the position of the index on a piece of paper stretched beneath it. Honourable Mention is awarded to this exhibitor.

Cazaux (Netherlands, No. 89) exhibits a dynamostater, intended for use as a dynamometer for ploughs, but applicable to the measurement of other strains, and furnished with a chronometric controller. It consists of two levers fixed to an iron frame, which mutually act on each other by a joint; to one of these the plough is attached, and to the other a counterpoise which constitutes one of the factors for the measurement of power, as it changes its position with a change of strain, which changes are marked as the lever moves.

The chronometric controller consists of two watches provided with second hands, one of which is unaffected by the pull, and merely indicates ordinary time, whilst the other is acted upon by the varying position of the lever, in such a manner that its rate per minute varies with the varying strain, and is self-registered. By this means all varying resistance is recorded, such as is experienced in the towing of a ship, &c., cases in which the ordinary dynamometer, acted upon by means of a spring, is found to fail.

Crystallography.

LEESON (Class I., No. 8) exhibits a very beautiful collection of crystals; the apparatus for illustrating the crystallographic speculations published by Dr. Leeson, in the third volume of the Memoirs of the Chemical Society; a double refracting goniometer; and numerous models of crystals. A Prize Medal was awarded to Mr. Leeson.

It is difficult to understand why the remark "rectangular" is annexed to a model labelled antimony. For according to the independent observations of Marx, G. Rose, M. Zippe, and Haidinger, antimony crystallizes from fusion in a form, the faces of which make, with each other, angles differing nearly two and a half degrees from a right angle.

MITCHELL (Class I., No. 9) exhibits a collection of crystals; some very beautiful card-board models of crystals, in which the faces of each have a distinctive colour, as in some of the plates of Tennant's Mineralogy, and are marked with symbols according to the notation adopted by different crystallographers.

Also some very ingeniously-contrived skeleton models, showing the outline of all the simple forms of a crystalline species, referred to the same axis.

Other models, some to illustrate theoretical views, are exhibited by Mr. Mitchell, according to which, the simple forms of crystals of any system may be derived from those of a crystal of the cubic or octahedral system. A Prize Medal was awarded to Mr. Mitchell.

LUHME (Prussia, No. 83) exhibits an extremely good collection of models of crystals, selected by G. Rose.

SCHRÖDER (Grand Duchy of Hesse, No. 77) exhibits models of crystals, described in Kopp's "Einleitung in die Krystallographie," on a large scale, which are probably the best-executed models that have yet been made: he also exhibits various models of geometric solids, which appear to be as well executed as the crystals. A Prize Medal was awarded by the Jury to Professor Schröder.

BATKA (Austria, No. 135) exhibits some very good models of crystals in glass.

BERTAUD (France, No. 1549) exhibits models of crystals.

Drawing Instruments.

VARLEY and SON (No. 257) have exhibited a graphic telescope and table, also a small graphic stand, adapted for use on an ordinary table.

The telescope is furnished with a variety of powers, and affords every variation of size in the object to be traced, which may be sketched to the true perspective distance of the picture on which it is to be placed.

The field of view is large, but the picture may be extended by moving the telescope, and shifting the paper, there being a means of applying correction, if necessary.

The paper or drawing surface may be placed in any convenient direction, and inclined at any angle, the instrument affording facilities for delineating objects in all positions, whether overhead, on the floor, or right and left. The image can be adjusted with equal precision at what distance soever the eye may be removed from the paper, and may also be reversed, for lithographic purposes.

This instrument has assisted in the production of the great "Panorama of London, as seen from the top of St. Paul's," at the Colosseum, in the Regent's Park, and in that of Corfu, the coloured sketches for which, on a large scale, were made by the late Joseph Cartwright, Esq.

The graphic telescope is designed to afford assistance to artists, architects, and draftsmen, by presenting to the eye a correct image of the object to be traced, in any direction and of any size required.

In order to trace telescopic images, great steadiness and portability are required. Both these requisites appear to be combined in the graphic table exhibited by Mr. Varley. The frame-work is so constructed as to be extremely light and steady; the joinings are made with hinges, from which the pins may be removed, and the instrument packed into a small compass. The table itself is supported upon a braced tripod, and admits of adjustment upon any surface, however irregular; it can also be supported at any angle.

Elliott and Sons (No. 320) exhibit a fine magazine case of drawing instruments, inclusive of all the recent improvements: the two trays with which it is furnished and the interior of the lid contain metal rulers, sectors, triangles, ivory sectors, parallel rules, pocket rules, a graduated joint for taking angles, &c. The metal sectors are well divided, as are also those made of ivory. In the drawers is a complete set of water colours. This set of instruments, the case of which is in itself a fine piece of workmanship, was rewarded with a Prize Medal.

The same exhibitors have another case of instruments, of good workmanship, and highly ornamented by engraving and chasing. They exhibit also various sets of ivory sectors, divided from 10 to 100 to the inch, and ivory parallel sectors, capable of being used on both sides, with divided edges both sides. They also exhibit a small instrument, called an opisometer, intended for measuring the length of curve lines. It consists of a small roller, which, having been passed over the lines, is made to perform the same number of revolutions over a scale.

Pillischer (No. 269) has exhibited an elliptograph. The principle upon which this elegant little instrument is made to describe an ellipse, is that of a point revolving in a circle about a centre, with an angular velocity the double of that with which the centre revolves about a fixed centre. The cogs on a moveable bar, and wheels of the instrument, are so arranged that the short arm which holds the style performs 100 revolutions while the long arm performs one. By varying the relative lengths of the two arms an ellipse of any form may be drawn. The semi-major axis of the ellipse will be manifestly equal to the sum of the two radii or arms, and the minor axis equal to their difference. A Prize Medal was awarded to Mr. Pillischer.

Simms (No. 741) exhibits an isometrical elliptograph. Invented by G. B. Airy, Esq., the Astronomer Royal.

Dobson (No. 323) has exhibited many well-made sets of drawing instruments, so far as could be seen through the glass case, which was never opened for the examination of the Jury.

Tree and Co. (No. 324) have exhibited some well-made drawing instruments, with many accurately-divided scales for different purposes. The Jury awarded Honourable Mention.

Parke and Sons (No. 319) have exhibited well-made drawing instruments, and several well-divided scales.

Dixey (No. 271) has exhibited several mathematical instruments, amongst which is a divided ivory rolling parallel rule.

Haggard (No. 328) exhibits a double protractor, intended for measuring angles, and determining heights and distances.

Graham (No. 355) exhibits an ivory rule, one foot in length, and an inch and a half in breadth, for the purpose of exhibiting by inspection the circumference of a circle when the diameter is given, and *vice-versâ*, and for showing the side of the square equal in area to that of a circle, whose diameter or circumference is given.

One side of the rule contains three lines extending its whole length, the upper side of each being divided into 100 parts. The under side of one is divided into 315 parts, 314 of which are equal, the remaining part being equal to 0·16, and the relation existing between the divisions above and below the lines being that of the diameter to the circumference of the circle.

The under side of the second line is divided into 89 parts, 88 of which are equal, the remaining one equal to 0·623. On the diameter of a circle being given, on the upper side, the side of the square whose area is equal to that of the circle of that diameter, is read at the same point on the under side.

The under side of the third line is divided into 283 parts, of which 282 are equal, and the other is equal to 0·095. The relation existing between these lines at the same point, is that of the circumference of a circle on the upper side, to the side of the square (to one place of decimals) equal in area to the area of the circle.

The reverse side of the scale is occupied by scales of equal parts.

It is understood that Mr. Graham has arranged other lines, showing the relation existing between the area of the circle when the diameter is given; and another giving the area when the circumference is given.

Matthias (No. 395) exhibits an instrument for dividing a given line quickly into any number of equal parts, less than 100, by a method susceptible of more extended use. The principle of the instrument is that of an angle and parallel lines, the angle being formed by the two legs of the instrument, which may be opened to the distance of 20 inches, any space less than which can be divided: it is made of ivory.

Horne, Thornthwaite, and Wood (No. 220) exhibit Tebay's universal planing rule, the novelty consisting in the arrangement of the division of the odd and even scales: by continuing the graduation to the edges, the necessity of making use of dividing compasses is obviated.

Gavard (France, No. 235) exhibits improved pentagraphs; the improvements, which consist principally in a better arrangement of the steadying weight of the pivot, and the larger size of the wheels, add greatly to the smooth working of the instrument, so much so that even persons unaccustomed to its use may produce smooth and unbroken lines. In the hands of Madame Gavard it performed several beautiful tracings of great delicacy and difficulty, among which we may specially mention a map of France, showing with great distinctness the departments, comprised within two inches square. The steadiness of the instrument when in use is very greatly increased by the improvements of M. Gavard.

Gavard also exhibits a beam compass of most finished workmanship, and an instrument for drawing from nature by mechanical means. A telescope with a cross wire in its focus is suspended in a jimbal frame, near the eye, and so as to keep the position of the eye nearly fixed. It is so balanced and so lightly hung as to allow the most perfect freedom of motion, and the cross of the wires being carried along every part of the outline of the object.

The object end of the telescope is suspended over a pulley on a vertical support, by a silk line, which is conducted to the base of one support, and thence along a horizontal bar to a pencil-holder sliding on the bar. Thus any movement in the vertical direction is traced on paper. To trace the horizontal movements in like manner, the upright support and the horizontal bar are made moveable on rollers to the right and left. The instrument is of most delicate execution, and works with perfect smoothness. As specimens of its performance are exhibited a tracing of a ceiling of the Luxembourg, of singular complexity; and a series of outlines, in illustration of the interior of the Palace of Versailles, with its rich and elaborate decorations, which are executed with exquisite fidelity and delicacy.

By adapting a microscope instead of a telescope to the jimbal frame, the outlines of a microscopic object, as of an insect, wood section, &c., can, in like manner, be traced with perfect fidelity, and on any scale. Honourable Mention was awarded to M. Gavard.

Lüttig (Prussia, No. 81) exhibits several cases of well-made drawing instruments, some in German silver and some in brass. The Jury awarded Honourable Mention to M. Lüttig.

Reifler (Bavaria, No. 34) exhibits a case of drawing instruments. An Honourable Mention was awarded by the Jury for his new method of fixing the two parts of a compass together by means of plane surfaces with steadying pins and screws.

Hommel-Esser (Switzerland, No. 81) has exhibited drawing instruments, distinguished for the care with which the most minute details have been finished. A Prize Medal was awarded to this exhibitor.

Gysi (Switzerland, No. 85) has exhibited drawing instruments: the remarks applicable to the preceding exhibitor apply equally to these; and it may be observed, that the steel used by both exhibitors is of the finest quality and extremely well tempered. A Prize Medal was awarded to this exhibitor.

Kern (Switzerland, Nos. 88 and 92) exhibits some well-made drawing instruments, which, in common with those of the Swiss exhibitors, are made in different parts, which can be readily separated and cleaned with ease. The Jury considered Mr. Kern as deserving Honourable Mention.

Imperial Ljorsk Works (Russia, No. 169) exhibit a full set of twenty-seven drawing instruments, comprising eleven different articles 5 inches in length; a set comprising ten pieces of 3 inches in length, and mounted in silver.

The following drawing instruments are exhibited, mounted in brass: a full set of twenty-four pieces; a set of eleven pieces 5 inches in length; and a set of ten pieces 3 inches in length.

The following pocket instruments are exhibited:—Folding or silver-mounted compasses; brass compasses in silver sheath; and several other compasses mounted in brass—some furnished with pencil-tubes, and mostly folding up. All these instruments are well made, and include the recent improvements: they deserve very Honourable Mention.

VIBERG (Sweden, No. 14) exhibits two small cases of drawing instruments, containing each a protracting semicircle, a pair of large steel-pointed compasses, two smaller for steel pens, on exchangeable pencil-points, and a steel ruling pen. They are very neatly made.

LITTMAN (Norway, No. 15) is stated in the Catalogue to have exhibited drawing instruments, but careful search being made for them, they were not found among the objects in this compartment of the Exhibition. (See Microscopes, Levels.)

NIETZCHMANN and VACCANI (Prussia, No. 706) exhibit many sets of drawing instruments, of an exceedingly low price. The Jury awards Honourable Mention for cheapness.

ROCHETTI (Austria, No. 136) exhibits a case of drawing instruments of sixteen pieces, compasses, &c., of brass and steel, of very elegant construction. There is no protracter, ruler, or scale.

PENROSE (No. 318) has exhibited registered screw and sliding helicographs for drawing volutes, scrollwork, and spirals of various kinds. The outline may be drawn on paper by means of an impression obtained from the disc by transfer-paper, either with ink or pencil, by the sliding helicograph. For a description of these delicate and well-constructed instruments, see the Illustrated Catalogue.

A Prize Medal was awarded to Mr. Penrose.

Orreries, Planetariums, and Astronomical Machines.

It is a matter of regret that the time and ingenuity which have been devoted to the several machines of this class in the Exhibition have not been better directed. Those exhibited do not indicate any improvement over the many which have been constructed, one only, perhaps, excepted, viz., a vertical orrery of large dimensions, made by a working man, after his own design, and it is understood, without ever having seen an orrery of any kind.

The time, ingenuity, and expense, devoted to machines of this kind, are wasted; they are of no use to the student of astronomy, and the erroneous impressions which they give are always displeasing to the eye of the astronomer.

If they be of any use in the lecture-room to children and novices, certainly Facy's vertical orrery is the best adapted for this purpose.

Orreries.

FACY (No. 195) has exhibited a vertical orrery, showing the relative periodic times of the planets. A comet's orbit is also introduced which extends from within that of Mercury to some distance beyond Neptune. The Jury voted a Prize Medal to Mr. Facy for the ingenuity displayed by him in the construction of this orrery.

NEWTON and SON (No. 212). An orrery, showing the motions of the earth and moon, the planets and their satellites. The mechanism by which these several movements are performed is actuated by clockwork. They exhibit a smaller orrery, constructed on the same principle, but showing only the motion of the earth and moon.

PLANT (No. 215) has exhibited an orrery, the sun being represented by a luminous body; the seasons, phases of the moon, and other natural occurrences are clearly shown. It may be used to the greatest advantage in a darkened room, when the sun of the orrery will best show the various changes attendant upon the different motions of the several bodies.

Planetariums.

NEWTON and SON (No. 212). A planetarium for educational purposes, intended to show the diurnal and annual motion of the earth and moon, also the respective position of their satellites. It is exhibited for cheapness.

LE FEUVRE (Jersey and Guernsey, No. 10) has exhibited an orrery; it is designed to show the motion of the moon around the earth, her daily variation and position at the time of new and full moon, also to exhibit the cause of eclipses, either partial or total. It is intended for the use of schools.

MASSETT (Switzerland, No. 95) exhibits a planetarium of an extremely simple construction, in which the motions of the sun, the earth, and the moon are shown. It is remarkable for its cheapness, and Honourable Mention was voted by the Jury.

MOLLISON (No. 585) has exhibited a pedestal planisphere. The places of the stars being perforated, when the instrument is held up against a light background, they appear as luminous points. It is 20 inches in diameter, and designed for educational purposes.

BAKER (No. 354) has exhibited the model of an instrument called a Periphan, designed for the simple elucidation of solar and lunar phenomena. It is furnished with a terrestrial globe in the centre, and is intended to describe the apparent diurnal motions of the sun and moon, also the daily increase and decrease of the sun's declination, and to determine the time of sunrise, at any place on the globe; the causes of the harvest moon, &c. The model is in diameter 6 inches, which is about a third of the proposed size. It consists of a fixed meridian circle graduated on both sides; on one similarly to the brass meridian of the common globe, and on the other to show altitudes; a horizontal circle, showing the zodiac signs, &c.; a terrestrial globe, placed in the centre of the sphere, which turns freely on an axis; two small pea globes, to represent the places of the sun and moon, and which slide on circular wires; these wires themselves turn freely in their bearings. This instrument shows readily the time of the sun rising and setting at any place exterior to the frigid zones, and various other phenomena of an analogous nature.

MATTHEWS (No. 193) has exhibited an Astrorama. This is a concave representation of the heavens upon a small umbrella, which opens and closes at pleasure. The material with which it is covered is perforated to show the places of the larger stars.

MALLOCH (No. 208) has exhibited a mechanical indicator for teaching geography. This is a contrivance for rendering purely mechanical the acquirement of the first rudiments of geography. A map is mounted upon a light frame-work a few inches in depth to permit the studs to work freely. These studs themselves represent cities, towns, &c. on the map, beneath which is placed an index giving the name of each place thus represented. On the same line with the printed name is placed a moveable stud. By keeping down one of the studs on the surface of the map, a corresponding one in the index instantly rises, the printed name beside it giving the required information.

This is an invention of Mr. Malloch's. The model which he has exhibited is, he considers, capable of still further improvement. Mr. Malloch also has exhibited a mechanical indicator of eclipses.

MURDOCH (No. 202) has exhibited an eclipse indicator. This is a circular table embodying by the motion of a circle of months on a cyclo-circle with intervals of 18 years 11 days, the actual results of a previous calculation of the moments of conjunction, both for lunar and solar eclipses from 1647 to 2001. The rules given for setting and reading off the circles being adhered to, the precise moment of the ecliptic conjunction and other particulars are obtained.

RYLES (No. 190) has exhibited an apparatus for showing the ebb and flow of the tide.

NEWTON and SON (No. 212). An armillary sphere, mounted on a brass meridian and attached to a brass stand.

ZIBERMAYR (Austria, No. 132). A chronoglobium and planetarium, a flat board on which are framed the orbits of Mercury and Venus. The earth and moon are attached to a small rolling carriage as described in M. Guénal's instrument, by which the rotation of the earth and the phases of the moon are represented. Mars is also made to revolve on his axis by a similar contrivance, viz., by establishing a rolling drag on the orbit.

DINK (Austria) exhibits a globe of the earth, about five inches in diameter, within a glass sphere, on which are placed the fixed stars. The positions of the sun and moon are marked at any given moment by a simple mechanism.

RICHARDS (No. 188) exhibits a "geographical instructor," a piece of mechanism in which the sun (represented by a gilt ball elevated on a wire) is presented vertically to every point of the earth between the tropics by a compound movement of rotation on a horizontal axis, the revolving ball being pulled and pushed along it, by a movement to and fro corresponding in extent to the time of the sun's declination at the moment. The law of this movement is given by a train of clockwork, of which one peculiarity is the prolongation of the axis of the globe into a very long pinion, so as to allow the teeth of the driving-wheel to act upon it, however far displaced from a mean position. Another, that of the communication of the rotary motion from the *primum mobile* by a hook-jointed axis; the to-and-fro motion of the pinion prolongation of the axis not allowing the clockwork to be centrically placed in some point in that direction.

DETOUCHE and HOUDIN (France, No 1589) exhibit a uranographic apparatus (erroneously described in the Catalogue as a monographic apparatus); it consists of a table about six feet in diameter, in the centre of which is a lamp representing the sun. The earth with the moon attached is carried round on an arm, by a piece of clockwork, the *primum mobile* of which is not a spring, or any internal power, but the roller on which the mechanism rests, and which revolves as the earth is carried round on the table. This, by a train of wheel-work, communicates to the earth its diurnal motion, preserves the parallelism of its axis, and gives to the moon all the movements imitative of real ones. This mechanism is the invention of M. Guénal.

Dialling.

Newton and Son (No. 212) exhibit a spherical sun-dial. The hour is indicated by means of the shadow of the pole or axis of the sphere being made to fall within-side the zodiacal belt, on the outside of which the signs of the zodiac are depicted. This is well adapted for a lawn.

The articles exhibited by Mr. Newton are distinguished by cheapness and good finish generally.

Lawrence (No. 115) exhibits a sun-dial applicable to all north latitudes.

Elliott and Sons (No. 322) exhibit a spherical sun-dial.

Darnell (No. 383) exhibits an universal sun-dial.

Cox (No. 347) has exhibited a portable instrument for ascertaining correct time by equal altitudes of the sun.

Uhlman (Netherlands, No. 85) exhibits an equatorial sun-dial made of copper, furnished with a moveable hour, minute-hand, &c., which, by suitable mechanism and a lens, may be made to discharge a piece of ordnance at any time required.

Globes.

Johnston, A. K. (No. 198) has exhibited a terrestrial globe, 30 inches in diameter; it shows the geological structure of the earth, indicates the currents of the air, trade winds, monsoons, &c.; also the currents of the ocean, trade routes, and isothermal lines, or lines of equal temperature. The stand, which was executed by N. Davidson, of Edinburgh, is carved in walnut, and is of elaborate and elegant design. A Prize Medal was awarded by the Jury for this globe.

Newton and Son (No. 212) have exhibited a large manuscript celestial globe 6 feet in diameter. The positions of the stars have been laid down from their positions as calculated for the year 1860.

Several pairs of globes ranging in size from 12 inches to 25 in diameter, variously mounted in different materials.

A glass case containing several small-sized globes, varying from 1 inch to 9 inches in diameter. These are all differently mounted.

A pair of 12-inch globes are exhibited for economy of construction, and improvement in the manner of mounting; the pole or axis of each globe remains stationary, whilst the horizon is moveable.

Slate globes are exhibited of various sizes, having the meridians and parallels of latitude marked upon them. The material of which they are formed affords the student means of filling in the outline map with common slate pencil. This is advantageous as applied to educational purposes. The globes exhibited by Messrs. Newton are distinguished by good finish generally, and by cheapness. A Prize Medal was awarded to them by the Jury.

Fletcher (No. 200) has exhibited a pair of terrestrial globes, and one case showing the various stages of globe-making. The contents of the case are as follows:—

1st. An iron mould: by the adoption of iron instead of wood, the material generally used, all danger of warping is avoided, and much time is consequently saved.

2nd. The axis of the globe.

3rd. The globe in its rough pasteboard form.

4th. A globe coated with composition, resting in an iron semicircle, the revolving in which gives its perfectly-spherical form.

5th. The engraved copperplate.

6th. The impression from the copperplates.

7th. The globe pasted and partly coloured.

The globes are well made and finished, and the process of globe-making, as exhibited by Mr. Fletcher, is interesting.

READHOUSE (No. 677) has exhibited a model of the moon in high relief, the craters, mountains, &c., being modelled from actual observation with a 1-foot reflector; power about 55, and the occasional use of a refractor power, 90 (the use of the latter being procured only at the expense of a journey of 35 miles). It merits commendation, though the scale of height has been pitched too high; and the effect is injured rather than improved by silvering or gilding portions of the surface, the whole being composed of a dark material.

ADORNO (No. 218) has exhibited a globe 25 inches in diameter, with the celestial and terrestrial maps superimposed one upon the other; also a globe of papier-maché, divided into forty-eight pieces, to be taken to pieces and rebuilt at pleasure; and a skeleton globe, to show how to rebuild the globe in its frame. The power of taking the globe to pieces is convenient for package and removal, as well as for the convenient study of any part of it. They are well made.

STOKER (No. 204) has exhibited an angular terrestrial globe, intended for the solution of geographical problems. It is adapted for use as a common terrestrial globe, by unscrewing the cog-wheel attached to the spindle at the south pole, and substituting the horizon and meridian, the former being screwed in the upright of the stand, the latter being placed upon the globe, the angular motion given to which is designed for the better explanation of the changes of the seasons.

Mr. Stoker also exhibits a spherical geographical clock, to show the difference of time between two given places whose longitudes are known, and is intended to be of more general use than those ordinarily constructed.

BENTLEY (No. 213) has exhibited a plain globe. The northern and southern hemispheres are printed on circular pieces of card-board, each hemisphere moving under a brass meridian, which confines it to its place, and affords the same facility as an ordinary globe for working problems.

PAXON (No. 191) has exhibited a lunarian, with a contrivance for showing the phases of the moon.

MARRATT (No. 185) exhibits a Russell's globe of the moon, mounted as originally sold, with movement in brass for exhibiting the librations, &c., in longitude and latitude.

GOOD (No. 146) exhibits a new method of illustrating the effect of the earth's diurnal motion upon the plane of a pendulum's oscillation. It consists of one end of a radius arm, fixed in the centre of a globe, the other end being adjustable in a vertical plane, and therefore to any latitude, is made to revolve so that its time of revolution varies as the sine of latitude ; the time of the revolution of the globe being its measure.

EDKINS and SON (No. 207) have exhibited a pair of 18-inch globes. They are well finished.

GILBERT (No. 234) has exhibited a portable celestial and terrestrial globe, made of tissue paper and inflated with air. The celestial globe is adapted chiefly for the use of the lecture-room, and may be made of any convenient size. The terrestrial is 12 feet in circumference, and is inflated either by means of an air-pump or by simply raising it to and fro from the floor, by which means it may be effectually filled in a few moments. These globes may be folded into a very small compass.

KUMMER (Prussia, No. 194) has exhibited a terrestrial globe in relief, 4 feet in diameter. The execution is excellent: not only have the elevations been attended to with great care, but also highlands of moderate elevation, and the courses of rivers, have received the same degree of attention. A Prize Medal was voted by the Jury to M. Kummer for this globe.

GOODYEAR (U. S., No. 378) exhibits inflated globes two feet in diameter, of India-rubber or silk, varnished with the former material. Also India-rubber maps.

GROSSELIN (France, No. 249) exhibits georamas and uranoramas, to be used as lamp-shades; also some very good and distinct celestial globes, in which the figures and constellation boundaries are neatly and prettily laid down, so as not to confine the representation of the stars.

ZIEBERMAYER (Austria, No. 132) exhibits a small terrestrial globe, enclosed in a glass sphere, on which the celestial sphere and stars, &c., are traced. By means of mechanism the places of the sun and moon among the stars are shown.

RIEDL (Austria, No. 131) has exhibited a small globe of the moon, about 10 inches in diameter; the engraving is of a sepia colour, somewhat faintly tinted, and of a seleno-topographical rather than a pictorial character. Some of the principal names are inserted. It is mounted on a brass pillar, with a horizontal circle showing lunar longitudes, and a vertical one for latitudes; the lunar axis is vertical.

Relief or Model Mapping.

DENTON (No. 317) exhibits specimens of model or relief mapping in its various stages, with all the tools necessary for use.

The base of the model exhibited is of slate, a material which may be procured of sufficient thickness to bear any weight in a horizontal position, may be ground sufficiently thin for framing, and may also be worked to the smoothest possible surface ; thus containing the qualities necessary for the work in question, the use and accuracy of which are dependent on the material upon which the superstructure is raised.

To erect the altitudes represented in the contour map, a simple mechanical process is adopted ; slips or ribbons of thin copper, cut parallel, of different breadths and of any length, are prepared. Each breadth represents a contour, and is proportioned to a certain elevation : after careful measurement with the altitudes which they are intended to represent, they are each adjusted and secured in their true position.

The model so prepared is ready for covering with plaster of Paris, a substance well suited to give a finished appearance to the work. After the plaster is dry, the whole should be scratched down until the light edge of each copper ribbon peeps to the surface. The model is thus prepared for the reception of the oil-colours intended to trace upon it the geographical details of the country.

Mr. Denton observes that it is not desirable to adopt a scale of less than 198 feet to the inch, and that the vertical scale of height should be carefully proportioned to the horizontal scale of distance. In thus exhibiting as he has done the details of a cheap, simple, and generally applicable method of surface modelling, Mr. Denton cannot fail to call increased attention to the subject.

The Jury have awarded a Prize Medal to Mr. Denton.

Schoell (Switzerland, No. 252) exhibits a model in relief of Mount Sentis and the mountainous regions around Appenzell, including a surface of about 150 square miles. It is executed with great spirit and distinctness, and is accompanied by a chart on a smaller scale of the same region (scale 1 to 25,000), containing the data for its construction, consisting of a minutely-elaborate series of contour or level lines, which covers the whole area, and is carried into every detail. The merit of the execution is enhanced by the plastic material of the model, as well as the apparatus used in its construction, being of the artist's own invention.

This work has been considered by the Jury to merit a Prize Medal.

Ibbetson (No. 459) exhibits an exceedingly well-executed relief model of the Isle of Wight, on a scale of three feet to one mile, the elevation being on the same scale. The geographical and geological features of the country are carefully delineated.

A Prize Medal was awarded to Captain Ibbetson. (Medal awarded also in Class VII.)

Aerial Machines.

Gilbert (No. 234) has exhibited the model of a char-volant or carriage drawn by kites. The vehicle is in appearance similar to an open and double-bodied phaeton, with this difference, that before the driver is placed an upright spindle, surmounted by a T handle, the lower part of which is square, and carried under the head of the carriage, and fitted into a small horizontal wheel, round which is placed a band, which communicates with a similar wheel, and is fastened to the pivot of the front axletree. Two kites are designed to act as the propelling power: the upper one is of the ordinary form, and is called the pilot kite; the lower one is so connected with the carriage that the driver possesses the power of varying its inclination to the wind at pleasure, an oblique direction being communicated to it by two additional lines attached, the one to the right, and the other to the left hand extremity of the shoulders of the kite. By these means the plane of the kite can be inclined to the direction of the wind, and the line of traction thus rendered oblique to the direction of the aerial current, so as to enable the charioteer to "haul on a wind," or steer on an angle considerably out of the line of the wind. It has been calculated that two kites, the one 15, and the other 17 feet in length, have power sufficient to draw a carriage containing four or five persons when the air is in quick motion.

This model deserves great commendation, as regards the elegance of its form and the lightness of its construction.

It is not impossible that under some circumstances the application of the propelling power of the kite may be useful, and at times attended with satisfactory results; but it would appear that as applied to nautical purposes it would be far more efficient than as a means of locomotion on land, the inconvenience attendant upon which must necessarily be great (the present arrangements not appearing likely in all their applications to carry out the sanguine hopes of their projectors); but as regards its application to vessels, it may often prove serviceable in obtaining the advantage of an upper current of air moving quickly when all beneath a certain elevation is calm. It is also likely to be of use in signalling from vessel to vessel, and might possibly serve in time of shipwreck to establish a communication with the shore; but that, with its present mode of manipulation and arrangement, it can take its place among the regularly-organized systems of conveyance is without doubt fallacious. Yet it ought to be mentioned that this ingenious and singular contrivance has been so far at least reduced to actual practice by the inventor as to have been exhibited, occasionally, for a great many years, running on the road between London and Bristol; the whole distance (113 miles) having been performed on one occasion in 1846 by a party of sixteen persons, in three such carriages, without accident, and with a speed occasionally as high as eighteen or twenty miles an hour. A member of the Jury recollects receiving from a friend, five and twenty years ago, the account of an excursion performed in such a carriage or carriages (as one of a party of nine persons), from Bristol.

LUNTLEY (No. 237) has exhibited the model of a rotary balloon, designed to be its own propeller by means of its peculiar shape, viz., cylindrical in the centre, and both ends formed into tapering screws. The balloon floats horizontally, and is intended to rotate by means of a band passed over its centre and worked by machinery in the car. The screw at one end is intended to draw, that at the other, to propel. By shifting the points of suspension, and thus altering the direction of the car, it is designed to guide its course through the air. This construction is intended, if possible, to overcome the direct atmospheric resistance encountered by the balloon in its progress, and to cause a more equal distribution of atmospheric pressure.

GRAHAM (No. 233) has exhibited an aerial machine designed to take any direction required: an axle suspended over the car, and worked by a strap communication from the car, carries at either extremity a system of fan sails, with expanding joints, allowing them to assume a more or less conical arrangement. Sails of a similar kind, of the nature of oars, project from either side of the car.

SADD (No. 301) has exhibited the model of an aerial machine. It consists of two cylindrical balloons placed horizontally, with revolving wheels, for propelling two floats, by which to raise or depress the machine at pleasure; and a rudder for the purpose of giving the required direction.

BELL (No. 715) has exhibited the model of a locomotive balloon. The car, which is in the form of a boat, is constructed with a buoyant apparatus at each end, so that in the event of its descending upon the sea, the balloon and machinery may be stowed away within it. Mr. Bell has also exhibited an improved valve for a balloon. Also the model of a locomotive parachute, equipped for service.

BROWN (No. 713) exhibits a balloon in which the gas expanding as the balloon rises is not suffered to escape, but is husbanded for use by being conveyed into the car, which is made large and hollow to receive it as a supplemental balloon. The car is also furnished at either extremity with two centrifugal bellows pointing obliquely outwards, by whose reaction, as the wind issues, it appears to be the inventor's design to impel and to guide the balloon.

Mason (No. 714) has exhibited the model of a navigable balloon, to be worked and directed by means of sails, helm, and mariner's compass. The model exhibited is upon a scale of a quarter of an inch to a foot. From what may be regarded as its after part, project laterally axles, giving a rotary motion to sails of the nature of screw-propellers.

Plummer (No. 716) has exhibited the working model of an aerial machine, furnished with wings or sails, put in motion by a clock-spring.

Calculating Machines.

There have been very many attempts to perform numerical calculations by mechanical means, or at least such parts of them as follow simple and rigid laws. Hitherto such instruments have failed to unite correctness in the results, combined with economy of time, and, for the most part, have been limited to the performance of the first two operations of arithmetic.

To make such instruments really useful, they must have the power of executing, by themselves, the successive operations for the solution of the problem imposed on them, when the simple data for this problem have been introduced, without trial, and without guess-work.

The best machine of this kind exhibited is that of Staffel (Russia 148), which, on examination, seems to combine accuracy with economy of time, and works easily and directly. The mechanism is 18 inches in length, 9 inches in breadth, and 4 inches in height, and consists of three rows of vertical cylinders; the first contains 13, the second 7, and the third 7. Upon each of the cylinders in the first row are 10 notches, corresponding with the units 1 to 10. Within each of these cylinders is a small pulley, in connection with a lever, set in motion by a slider which, when the cylinder has been turned from either 9 to 0, or 0 to 9, sets in motion the lever, and communicates its action to wheels, which carry over the figures. The pulley connected with the cylinder, the furthest from the handle, is in connection with the hammer of a bell. The purpose of this bell is to give warning to the operator, on committing an error, and constitutes a most important addition to the machine, particularly in the operation of division.

Upon each of the cylinders in the second row 10 units are placed. These seven cylinders are so fixed upon their axes, that they can bodily be moved right and left, and fixed at any part, so that the ciphers in the two cylinders can be made to correspond. This cylinder is furnished with a spike, which lays hold of and works the third row of cylinders.

The internal communication of each of the parts is brought about by means of a connecting wheel, furnished with 9 moveable pegs, which are set in motion by means of an eccentric incision in the dial.

The machine is capable of performing addition, subtraction, multiplication, division, and of extracting the square root.

The operation of addition is performed as follows:—

By simply placing one line of the numbers upon the second row of cylinders (the index pointing to addition), and turning the handle till it stops, these numbers are transferred almost instantly to the first row of cylinders, and so on successively, till all the numbers to be added are transferred, and their sum is shown on the top row.

In performing subtraction, the first part of the operation is the same as in addition, but on placing the second line of figures on the second row of cylinders, the pointer being placed to subtraction, the handle is turned the opposite way, or against the motion of the sun, and the difference of the two numbers is shown on the upper line.

The operation of multiplication is performed by placing the multiplier and the multiplicand on the second and third rows of cylinders, and then, the index pointing to multiplication, the product will be found on the first cylinder.

The operation of division is very similar, excepting that the handle is turned as in subtraction.

These several operations were performed accurately, and with despatch.

In the performance of the square root, the following additional mechanism needs explanation. Between every division of the cylinder, in row 2, a small wheel is placed, and near it a projecting piece which acts upon a lever; when the projecting piece is near the word "rad" engraved on the cylinder, on turning the handle, the figures increase by 1. This, by other mechanism, is connected with the other two rows of cylinders. The operation of the square root is performed directly, without any guessing at numbers; but it is, comparatively, rather a long process.

Upon the whole it must be considered that Mr. Staffel has made an instrument possessed of considerable powers, and that great praise is due to him. The double motion of the handle as well as the warning bell are important improvements.

Mr. Staffel also exhibits a small mechanical machine for the performance of the addition and subtraction of fractions, whose denominators are 10, 12 and 15. By enlarging the machine, this number would be increased, and the power of the instrument extended. The operations were performed with quickness, and with accurate results. A Prize Medal was voted to Mr. Staffel.

Thomas de Colmar (France, No. 390) exhibits the next best calculating machine in the Exhibition, and has combined the two essentials of economy of time and accuracy of results. It is adapted for the performance of the four first rules of arithmetic; and indirectly the square root may be extracted by the knowledge of $a^2+2ab+b^2$, the results being inferred; but this is not the legitimate use of the instrument.*

The instrument is adapted for the multiplication of numbers whose product is expressed by less than 16 figures, and consists of two rows of cylinders, the one containing 16, and the second 8; the former are moveable, the operation at each step being changed tenfold.

The principle of the instrument is, that multiplication is in reality the continual addition of itself as many times as there are units in the multiplier, and division that of continued subtraction of the divisor.

* For a description of this ingenious and useful machine, see the report of M. Benoit, au nom du comité des Arts Mécaniques, Société d'Encouragement.

On trying the machine, the number 1 was almost instantaneously taken from 10,000, giving the difference, 9,999, accurately; the performance of this operation is generally a severe test to these machines.

The number 5,321 was multiplied by 3,256 in less time than was required to perform the calculation, in the manner following:—The number 5,321 was placed on one series of cylinders, and the number 6 was placed on one of the cylinders of the second row, and on the handle being turned (in one direction always) the number 31,926 appeared; the upper row was moved through one division, the handle again turned, and so on, till, in a very short time, the number 17,325,176 appeared.

The several operations to which the instrument was subjected were performed quickly and accurately.

A Prize Medal was voted to M. Thomas De Colmar.

WERTHEIMER (No. 387) exhibits several calculating machines, adapted for the performance of addition and subtraction of numbers and moneys, of this and of other countries.

Each machine consists of a box, with a metal plate divided into nine indexes, with semicircular notches, under which are placed a succession of holes. Round the indexes, numbers are engraved, and the semicircular notches are furnished with teeth, and a pointer to insert between the notches, for the purpose of bringing the notch opposite any particular figure, from right to left. This operation is dangerous, for the notch is liable to slip and not go home.

The instruments are ingenious, but they are much wanting in the essentials of such machines, viz., economy of time and unerring accuracy. The Jury, however, voted Honourable Mention to them.

SCHILT (Switzerland, No. 59) exhibits a simple calculating machine, but which can perform the first operation of arithmetic only. Honourable Mention was voted to Mr. Schilt.

ROOKER (340) has exhibited a sliding scale of involution, the invention of Dr. Roget. The instrument consists of one fixed and one moveable scale, like a sliding rule. On the slide a line is logometrically divided, the divisions of one half being from 1 to 10, and repeated on the second half in the same order.

The fixed scale is graduated in such manner, that each of its own divisions is set against its respective logarithm on the slider, and, consequently, all the numbers on the slider will be situated immediately under those numbers in the fixed scale, of which they are the logarithms. Thus, 3 on the fixed scale will stand under 100 on the rule, and so on.

The instrument is adapted to perform the operations of involution and evolution. The principle of the instrument is contained in the equation,

$$\text{Log. log. } a^x - \text{log. log. } a = \text{log. } x.$$

From the first member of which a disappears. Two differences of the second logarithms of the power and of the root being equal to the first logarithms of the index, it is evident, that if a scale of second logarithms be engraved on one line, and a first on a line sliding along it, the indexes being read off on the latter, the power will be so on the former.*

* See "Philosophical Transactions," for the year 1815.

LALANNE (France, 1690) exhibits a calculating rule, constructed upon new principles, consisting of a graphic table formed entirely of right lines, with which all calculations, usually performed by the sliding rule, can be performed to within 1-200th of the true result. The Jury awarded Honourable Mention to this Exhibitor.

Instruments for the Use of the Blind.

HUGHES (401) has exhibited a portable typograph or writing machine for the blind.

This is a beautiful mechanical contrivance (by no means difficult in use) by which a blind person is enabled to print legibly, with ease and rapidity. It is also applicable to printing uniform labels for museums, &c. (for description see Illustrated Catalogue). The following is the manner of using it. The paper intended to be written upon is placed within a portfolio, one side of which is made of semi-carbonized paper, which, being durable and inexpensive, serves for ink. Having done this with the first finger of the right hand, any required letter, figure, or point of the index circle is brought to the right side of the lever, the thumb being inserted in the end of which, presses it downwards. This pressure will give the impression of a corresponding type letter acting upon the back of the transfer paper. The next operation is to lift the lever to its utmost height, which motion makes the space required for the next letter, and so on to the end of a word. A repetition of the movement will also make the space between the words.

Having finished a line of writing, the index circle is pushed back to the left side of its frame, and the thumb-screw turned for the desired distance between the lines; one whole turn of this screw, giving four lines to the inch.

The typograph is about the size of a quarto book, and does not occupy a surface of more than 12 inches square. Its inventor has done good service, having the merit of exhibiting the best machine for the same purpose, it being the most simple in its operations of any in the Exhibition. The Prize Medal was awarded to Mr. Hughes.

TOLLPUTT (382) exhibits a machine for facilitating the writing of the blind.

FOUCAULT (France, 220) has exhibited a printing machine for the blind. It consists of a fan composed of 26 rods, terminated at the upper extremity with the letters of the alphabet arranged successively, together with other rods terminated with the various ciphers and symbols required in printing; the lower extremity of these rods is furnished with a corresponding letter, &c., to the one above, but in smaller type. On pressing the larger character at the upper extremity, the smaller letter beneath is proportionably depressed, which causes it to leave its printed impression on a paper previously prepared. By a little contrivance the paper is made to move onwards, in proportion to the successive pressures from above. The exhibitor of this machine, himself blind, has the merit of being its inventor, and he was awarded the Prize Medal.

THOMPSON (United States, 461) has exhibited an invention for teaching the blind to draw and write. This device is simple, and intended to afford a means to the blind of acquiring knowledge of various kinds.

The writing tablet is covered with white leather, a material well suited to the purpose intended, as it yields to the pressure of the style without retaining the impression.

The style may be made of any hard material capable of receiving and retaining a rounded smooth point. The paper should be of a strong and rather firm texture, but at no visit of the Jury was any explanation given, and they are unable to speak further of this invention.

Gall (687a) has exhibited a triangular alphabet for the blind. This is an improvement on the Parisian, Austrian, and other circular alphabets, and it is probable that adult blind persons may by its means be easily taught to read. A volume containing the Epistle to the Ephesians, in the same characters, was exhibited, and Gall's apparatus for the writing of the blind, by means of which they can correspond with each other by post, as described in the Illustrated Catalogue.

Marchesi (Austria, 139) exhibits a circular printing machine, by which the blind can print readily with three different kinds of type. On examination by the Jury, it elicited much commendation, and a Prize Medal was awarded to M. Marchesi.

Miscellaneous.

Dunin (No. 210) has exhibited a piece of mechanism designed to illustrate the different proportions of the human figure. This beautiful piece of mechanism resembles in outward appearance a well-formed human figure, standing erect. It is capable of both considerable expansion and contraction in all its parts. The internal mechanism is completely concealed, the figure externally being composed of a number of thin slips of steel and copper, which overlap each other in proportion to the amount of expansion or contraction exercised. The motion these slips are made to possess is communicated to them by thin metal slides to which they are attached within the figure, the slides being furnished with projecting pins at their extremities. These pins are inserted into curved grooves, cut in circular steel plates, the curvature of the grooves being so arranged, that when the steel plates are put in revolution by a train of wheels and screws, the slides belonging to the several parts of the figure are expanded or contracted in correct proportion. The external slips of metal are disposed as much as possible in the direction of the fibres of the muscles in the living subject, in which direction the two motions of contraction and expansion are severally performed. Where in nature the fibres of the pectoral muscle converge towards the shoulder, in the figure there is much compound internal mechanism, and very ingenious external arrangement; the contraction of the chest, the back, the shoulder, and the fore-arm, are performed either simultaneously, with great accuracy and just proportion, or each part can be separately adjusted if required. These adjustments, the most compound and difficult to be overcome, Count Dunin by a new and most ingenious combination of mechanism has successfully achieved. The dimensions of the figure are subjected to their respective variations by the establishment of a connection between several parts of the internal mechanism and a winding key, by means of circular-headed projections, which being turned to the right or left, gently and gradually effect the contraction or expansion of the adjacent parts of the figure. The motions we have just described, are performed by the introduction of the winding key into several apertures left for its reception: one of them is situated immediately between the pectoral muscles on the chest; other apertures situated in the back, on the top of the shoulders, in the arms and legs, serve for the different adjustments required: about the knee of the figure, the movements of which are regulated by an aperture in the thigh, the workmanship and mechanical ability displayed are very great. The thin external metal slips, which overlap one another very considerably when the figure is quite collapsed or contracted, are each furnished with a long slit or cut-out groove, through which the pins from the plates beneath are seen to project. As these slips move easily over one another, it follows that when the figure is fully expanded, the slips can overlap one another scarcely at all; and thus the power of variation in the dimensions of the figure is dependent upon the individual length of these pieces of metal and their cut-out grooves.

The apparatus itself is not unlike in its general appearance to a fine suit of armour, displaying as it does the just proportions of the human form, deficient only in the extremities. The entire machinery is totally concealed, and works noiselessly, and though the entire mechanism is of the most compound nature, the whole is easily managed and adjusted. In addition to the general adjustments which we have described, we may observe that every part of the figure has an independent adjustment by which it can be put out of proportion, and made to represent the deformities or peculiarities of form of any individual.

We availed ourselves of an opportunity of carefully examining the interior of the mechanism of a similar figure in the work-room of Count Dunin, it being impossible to obtain any correct idea of its internal construction from an external view of the figure as exhibited. This examination enabled us to form a high estimate of the genius and mechanical knowledge Count Dunin has displayed in its construction. The mechanical combinations and parts employed are very numerous; they are as follows:—875 framing pieces, 48 grooved steel plates, 163 wheels, 202 slides, 476 metal washers, 4828 spiral springs, 704 sliding plates, 32 sliding tubes (to assist in the elongation of some parts), 497 nuts, 3500 fixing and adjusting screws, besides many other small pieces. The figure is maintained in its vertical position by means of a strong iron support at some distance from and affixed to its back.

The invention, which is stated could easily be made available in the artist's studio, is designed to facilitate the exact fitting of garments, especially where great numbers are to be provided for, as in the equipment of an army, or providing clothing for a distant colony, and will enable the personal attendance of individuals to be dispensed with, as from a new system of measurement the figure may be adjusted to the exact form and size of the person to be fitted.

A Council Medal was awarded to Count Dunin for this beautiful piece of mechanism.

LLOYD (No. 322) has exhibited a typhodeictor, or storm-pointer, an instrument designed to determine, by inspection, the bearing and relative position of a revolving storm, or hurricane.

The instrument is composed of a ring of metal, upon which the several points of the compass are engraved: attached to the centre of the circle, around which it easily revolves, is a larger pointer, with the words " set this to the wind " upon its face; in addition to the pointer, two hands of a transparent horn are likewise made to move round the central point, one being designed for use in the northern, the other in the southern hemisphere; but both are intended to mark the ship's place. Each arm is perforated with a succession of small holes, for the adaptation of the instrument to charts of different scales. In the centre is a revolving glass, which, resting on a moveable centre and pivot, is made to revolve to the *left* when in the northern hemisphere, and to the *right* in the southern; it is designed to illustrate the revolution of the winds around their centre, and to determine the relative position of a ship to the centre of a storm.

It having been ascertained by Colonel Reid that storms have a progressive and revolving motion, and that on opposite sides of the equator they revolve in opposite directions, the centre of the storm being nearly a calm, it follows that the ship can be but in one position with regard to its centre, and that, in the event of the ship approaching the storm, or the storm approaching the ship, the edge or outer boundary of it must be first encountered.

For the purpose of affording to seamen a practical illustration of the revolving winds, circles showing the gyrations of a storm, with directions for use upon them, have been made on paper which, for conveniency, has been rendered transparent; but these only prove useful in the case of a circular storm, and would fail entirely in a progressive whirlwind. Colonel Lloyd has the merit of supplying this want, and the Prize Medal was awarded to him by the Jury.

CHALLIS has exhibited an instrument for calculating the sum of the corrections of the three errors of a transit instrument, adapted for the latitude of Cambridge, and for any given N. P. D. The manner of determining these corrections is dependent upon certain geometrical considerations fully detailed in the "*Proceedings of the Royal Astronomical Society*," Vol. x., No. 8. The instrument consists of a brass circular plate, moveable about a vertical axis, passing through its centre; on the plate are engraved lines for the purpose of taking account of both positive and negative corrections. At a short distance from the circular plate is a contrivance for guiding the motion of two bars, which carry two fine parallel threads of blackened unspun silk on the surface of the plate. The interval between the threads is made equal to the collimation error by means of a scale engraved on a brass plate, to which one of the bars is attached, and an index is fixed to the brass plate to which the other bar is attached; the two plates are clamped together by a screw; when the threads are set to the required interval, the screw-head serves for a handle by which to move them. The circle is graduated, for showing north polar distances both above and below the pole. The method for performing the calculations and various details in the construction of the machine are fully described in the paper before referred to.

With regard to the degree of accuracy of which the machine is susceptible, Professor Challis observes, that for calculating the reduction to meridian transit, it has been usual to form a table of the coefficients of the collimation level and azimuthal errors, arranged according to the north polar distance, whence the coefficient for a proposed N. P. D. may be readily deduced; for the sake of saving time, the multiplication having been performed by a sliding scale. The usual method may be inaccurate to one-hundredth, or even two-hundredths of a second, whilst the machine by moderate care will give the nearest hundredth of a second. The indications of the instrument, however, become more uncertain in proportion as the north polar distances are less, on account of the small inclination of the threads to the correction scale: to meet these cases an additional scale is engraved, near the contrivance which gives direction to the threads.

Should the instrument be required for use in a latitude different from that for which it was constructed, a slight addition is required, but one which the instrument is made to perform itself. Professor Challis observes, that the machine, which requires no little nicety of work, was executed for him by Mr. Simms in a very satisfactory manner.

A Prize Medal was awarded to Professor Challis.

Blunt (No. 372) exhibits a model of Erastothenes, as seen through a reflecting telescope of 9 inches aperture, 7 feet focal length, and magnifying power 380.

The model is beautifully executed, representing very accurately this part of the moon. The large crater-like cup, with the neighbouring mountains and smaller cup-like valleys in their neighbourhood, are well shown. A Prize Medal was awarded to Mr. Blunt.

Spratt (United States, No. 5), has exhibited lightning rods. These rods in their cross sections are similar to the letter X, and are made either of copper or of iron. The points are formed of a compound of platinum, silver, silex, antimony, bismuth, and tin, mixed in certain proportions. The extreme top being of solid platinum is calculated to resist atmospheric decomposition. The base is furnished with three angular cast-steel magnets, plated with gold, one being also affixed to the brass connections at every point, for the purpose of facilitating the silent discharge. Zinc rings are placed between these joints to prevent oxidation.

The fastenings and glass insulators, also exhibited, are designed to afford greater convenience for the attachment of the lightning rods. Owing to this invention being in process of registration, the Jury were not able to examine it at the proper time.

Nasmyth (No. 688) exhibits a well-delineated map of the moon on a large scale, which is drawn with great accuracy, the irregularities upon the surface being shown with great force and spirit; also separate and enlarged representations of certain portions of the moon as seen through a very powerful telescope: they are all good in detail, and very effective. A Prize Medal was awarded to Mr. Nasmyth.

Fisher (United States, No. 263) has exhibited a "dial of the seasons," intended to illustrate the sun's declination at all seasons, together with the coincident effects of light and heat upon animal and vegetable life in all climates.

The chart is divided into two portions by a line crossing the picture horizontally. The upper corner to the extreme left is made to serve as the apex of the triangles, formed by lines drawn from it to the boundary line; these, by their verticality over the tropics and gradually-increasing obliquity towards the polar regions, illustrate very clearly the different amount of sun-light distributed over equal degrees of latitude, and the difference of temperature consequent upon this unequal distribution. The chart gives also a comparative view of the equinoctial and solstitial angle of sun-light, and is designed to show the comparative rapidity of the sun's declination at the spring and autumnal periods of the year.

The effect of the unequal distribution of sun-light is shown by a series of coloured illustrations, placed immediately beneath the boundary line, which, forming the base successively of the various angles, becomes in a measure graduated. The several degrees of latitude between these graduations contain the principal productions, either animal or vegetable, which may be considered strictly indigenous: thus, towards the equator, are shown the palm-tree, the coffee-plant, the tiger, &c.; in the polar regions to the north, the white bear, pine-tree, Laplander, &c.; whilst the temperate latitudes are characterized by the various animal and vegetable productions with which we are most familiar. Immediately beneath these illustrations is another parallel series, representing on the ocean the corresponding ranges of temperature from the tropics to the poles; indicated by the typhoon in its progress, the storm of the temperate latitudes, aurora borealis, the volcano of Mount Hecla, &c. The chart which is carefully executed, and well suited for educational purposes, is 2 feet 9 inches by 1 foot 4 inches. The book accompanying it is of considerable length, but too diffuse for educational purposes. It contains a detailed description of the diagram, and towards the conclusion an interesting table showing the influence of climate upon intellectual development, confining the existence of men of genius to within certain parallels of latitude: it is pleasingly and well written, and were it within our prescribed limits, fairly entitled to a favourable review.

Leyser (Saxony, No. 16) exhibits Weber's electro-dynamometer, for measuring the intensity of galvanic currents.

The instruments employed by Ampere in his electro-dynamical researches are not capable of affording very accurate results from the friction overcoming either wholly or in part the electro-dynamic force to be measured. Under the most favourable circumstances the utmost that these instruments can perform is to enable the feeble electro-dynamic forces to overcome the friction; but in every accurate measurement it should be assumed that the friction is an insignificant fraction of the force to be measured.

In order to exclude friction, the electro-dynamometer was contrived by Professor Weber. It consists essentially of two coils of wire covered with silk; one of these has 650 feet of copper wire, making 1,200 turns round a slender ivory spindle, 0·79 inch in length, and 1·26 inch in diameter. The ivory spindle on which the coil is wound is attached to a slender stump of brass, which carries a circular plane mirror about 1·1 inch in diameter, and also an index about 1·1 inch in length, beneath which is a circle having a graduation of about the same diameter. The two ends of the wire forming the coil are attached to the lower ends of two fine silver wires 19·7 inches, and 1·27 inch distant from each other, by which the stirrup and coil are suspended, with the axis of the coil horizontal, like the bifilar magnet, for measuring variations of the horizontal component of the earth's magnetism. The second coil has 980 feet of wire, making 900 coils round a thin hollow brass cylinder 1·73 inch in diameter, and 1·73 inch in length, placed with its axis horizontal, bisecting, and bisected by the axis of the suspended coil. The two coils are surrounded by a case having an opening, covered with plate-glass, through which the mirror attached to the suspended coil can be viewed. A vertical glass tube, 1·65 inch in diameter, and about 19·7 inches in length, ascending from the middle of the case, carries at its upper end insulated attachments for the upper end of the suspended wires, with adjustments in height and distance from each other, and a motion round the axis of the glass tube.

The case is fastened to a circular plate 5 inches in diameter, which has an azimuthal motion on a pedestal 6·7 inches in diameter, provided with 3 foot-screws for horizontal adjustments. The upper end of one of the suspending wires is connected by a conducting wire with one end of that of the fixed coil; the upper end of the other suspending wire is connected respectively with the poles of a voltaic element or battery; the current will hence traverse the whole of both the fixed and suspended coils. At a proper distance is placed a horizontal paper scale of 19·7 inches, the image of which, by reflection, is seen in the mirror attached to the suspended coil, and viewed through a telescope placed immediately below the scale, so that the angular displacement of the suspended coil, produced by the mutual action of the currents traversing the two coils, can be measured with great precision.

By means of an instrument, similar to that exhibited, Weber obtained a most accurate experimental proof of the mutual action of voltaic currents on each other.

The electro-dynamometer serves to measure the intensity of a voltaic current, as does a magnetometer, under the influence of a coil through which the voltaic current is transmitted; but the electro-dynamometer differs from the magnetometer in some very important particulars, the one supplying many of the deficiencies of the other.

In the magnetometer the tangent of the deviation is proportional to the intensity of the current; in the electro-dynamometer it is proportional to the square of the intensity of the current.

A change in the direction of the current causes the magnet to move to the other side of its position of equilibrium: when not acted on by the currents it does not affect the position of the electro-dynamometer.

The electro-dynamometer has been employed by Mr. Weber to measure the intensity of the oscillations producing sound. By including a magnetometer and an electro-dynamometer in the same circuit, he was enabled to determine both the duration and intensity of momentary currents, such as those produced by the discharge of a Leyden jar. Results, highly valuable as determining the effects of momentary streams in animal physiology, may be obtained by similar observations.*

The instrument is exhibited by Leyser, to whom much praise is due, not only for the workmanship, but also for many details which he has introduced in its construction.

Engel (Berlin, Prussia, No. 274) exhibits a well-executed wood model of Fresnel's wave surface, in viaxal crystals, and an ellipsoid of three unequal axes marked with the lines of curvature. A Prize Medal was awarded.

Ward (No. 664) exhibits his botanical cases, which are fully described in the Illustrated Catalogue. A Prize Medal was awarded to him.

De la Rue (Class XVII, No. 76) has exhibited various applications of iridescent films to the purposes of decoration, their vivid colours being produced simply by the agency of light upon a thin, transparent film of varnish. The process

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* See Weber's Elektro-dynamische Maasbestimmungen, insbesondere wider stands mes-sungen. Leipzig, 1850. And also Poggendorff's Annalen, B. 73, S. 193.

adopted to render the film and its reflected colours permanent, together with the method of its application, are as follows :—

The objects to be ornamented, whether insects, shells, birds, bronzes, paper-hangings, card-cases, &c., are immersed in a vessel of water. Upon the surface of the latter, when perfectly tranquil, is dropped a little oil or spirit varnish, which, spreading in all directions, becomes exceedingly attenuated, and reflects the most vivid colours of the spectrum. The varnish being fixed, the object, which is slowly raised in such manner that the film shall adhere to its surface, is then placed in a convenient situation, to permit the water draining off. When completely dry the film is found to be firmly attached, and perfectly iridescent, having lost nothing of its original brilliancy of colouring. This is a beautiful illustration of the production of colour on a thin transparent surface, by the slight agency of light, such as is transiently seen in an ordinary soap-bubble. The Jury awarded a Prize Medal to Mr. De la Rue.

VAN SCHENDEL (Belgium, No. 173) exhibits an exceedingly-good illustration of the laws of perspective, consisting of a series of objects, of exaggerated forms and dimensions, painted upon a horizontal plane and two vertical planes. At a certain height above the picture there is a circular hole, cut in a small wooden frame, on looking through which, the objects assume a natural appearance, in strict accordance with the rules of perspective, and appear in the most perfect relief. A Prize Medal was awarded to Mr. Van Schendel.

FISHER (United States, No. 263) has exhibited "mathematics simplified," consisting of some beautifully-drawn diagrams, intended to facilitate the study of mathematics. His idea is that of teaching a physical geometry either preliminary to, or, when no better may be had, instead of the science. His method of using the diagrams is by teaching each step by a course of reasoning, and illustrating the laws by well-drawn figures.

Nobody can question the great disadvantage under which students lie who have to apply geometry graphically, if their previous figures have been drawn only by hand ; or, what is worse, if badly drawn by ruler and compasses. It is doubtful which of the two is the greater evil—the giving a student ruler and compass as part of his course of geometry, or the making reasoning on badly-drawn figures the only preparation for a draughtsman or architect, &c. This has been often said, but seldom accompanied with any proof of the very satisfactory use which may be made of well-drawn diagrams. Mr. Fisher has the merit of offering this proof to the Exhibition, with some ingenious ideas as to the manner in which the details may be managed. The attention he has paid to one point, viz., the exhibition of areas of given simple ratios under the same and different forms is particularly beneficial. Some of his diagrams are, in this respect, excellent studies for an eye which is to be trained to correct estimation. This method is particularly applicable for adults possessed of a power of thought, which requires to be enlisted and exercised to make their study agreeable or even profitable.

Mr. Fisher's merit may be described as consisting in—1st, the application of the idea of teaching by physical perception, to a wider range of subject than merely making very exact drawings of the propositions to be demonstrated in Euclid ; 2nd, in the ingenuity of his details ; 3rd, the beauty of the drawings. The Jury considered Mr. Fisher deserving Honourable Mention.

Perigal (No. 693) has exhibited a demonstration, by the transposition of parts, of the theorem of the right-angled triangle. The square or base of a right-angled triangle being intersected by two straight lines, passing through its centre, parallel and perpendicular to the hypothenuse is, thereby, divided into four parts equal and similar to each other: which, being symmetrically arranged around a square equal to that on the perpendicular, form therewith a square equal to that on the hypothenuse of the right-angled triangle conversely. The sides of the hypothenuse square being bisected, and the points of the bisecting lines being drawn (till they meet) parallel to the base and to the perpendicular, the hypothenuse square is thereby divided into four equal quadrilaterals, which are together equivalent to the square or the base, encompassing a square equal to that on the perpendicular. Thus proving that "in a right-angled triangle the square of each side is equivalent to the *sum*, or to the *difference*, of the squares of the other two sides."—*Euclid*, i. 47.

Mr. Perigal has also exhibited a quadratic trisection of the square. The square is divided into nine parts of three different shapes and sizes; so proportioned that, by combining together one of each of them, they will form three equal squares, each one-third the area of the square formed by the whole nine sections. The construction is scarcely susceptible of brief explanation without a diagram.

Mr. Perigal likewise exhibits diagrams of the *retrogressive* parabola, as derived from the circle, $y = R \cos \phi$; $x = R \cos 2\phi = R\,(2\cos^2\phi - 1) \therefore 2y^2 = R\,(R + x)$. The origin of co-ordinates at centre of circle, radius R. The kinematic curve, of which the retrogressive parabola is a limit, was discovered by Mr. Perigal, in 1835, and produced from continuous motion by him in 1840.

Mr. Perigal has also exhibited a lunarian, of novel construction, which he calls a "selenescope;" intended to elucidate the kinematic effects of the three hypotheses which have been advanced to account for the inhabitants of the earth never having seen more than one half the surface of the moon, the same hemisphere of our satellite being always presented towards the earth. For this purpose, a terrestrial globe (about 3 inches diameter) is fixed on a brass stem supported by a brass pedestal. At the bottom of the stem is a fixed wheel of forty-eight teeth; and, between that and the pedestal, a T-shaped brass arm is centred, having at one end a receptacle for a mariner's compass. The other extremity of the arm is grooved to receive four arbors, with each a wheel of forty-eight teeth, like the fixed wheel first mentioned, into which one of them is made to gear. Another wheel in the middle of the cross part of the T gears into the second, and a fourth at the extremity into the third; while the fifth occupies a position at the opposite end of the cross groove, but does not gear with the other wheels. All these wheels have the same number of teeth. To the third, fourth, and fifth wheels are attached spindles, each carrying an ivory ball (about one inch diameter) representing the moon, at such elevation that their centres and that of the globe, representing the earth, may be all in the horizontal plane.

Carried by the arm round the fixed wheel, into which it gears, the second wheel is constrained to turn round its axis or arbor in the same direction, driving the third wheel in the contrary direction, by which the fourth wheel is driven in the same direction as that of the revolving arm; all with the same angular velocity: while the fifth wheel, not being in gear with the others, revolves with the arm without any additional rotation on its own arbor or axis. A coloured spot upon each of the ivory moons tends to render their relative motions more perceptible and distinct.

By this means one of the moons is caused to rotate on its axis in the same time, and in the same direction in which it revolves; another is caused to rotate on its axis in the same time in the contrary direction to which it revolves; while the third moon revolves about the earth, but does not rotate round its own axis.

Mr. Perigal also exhibited a gyroscope; an instrument designed to illustrate the effects of revolution and rotation. On a brass pedestal, an arm, supported at one end by an axis round which it freely revolves, carries at its other extremity a globe (about one inch diameter) representing the earth or the moon, which is flange-jointed in the middle, in order that the globe may be placed over the axis or centre of motion, and at various distances, as the experimenter requires.

GERARD (No. 109) has exhibited a spherical trigonometer, for the mechanical solution of problems in spherical trigonometry and nautical astronomy. The instrument consists of three legs, jointed together nearly as in the common triangular compass, and in such manner as in every position to point to a common centre, and to represent three radii of a sphere: three graduated arcs form the sides of the spherical triangle. In use an angle is measured by clamping a brace upon the sides containing it, and sliding the other to 90° upon three sides. The instrument is coarsely constructed, but its principle is good, and if better made would be very useful; the Jury consider it well deserving Honourable Mention.

DEMANET (Belgium, No. 178). Conversion of vibrating into rotatory motion. This is done by the inertia of a bob-weight on a horizontal arm attached to an axis which has a fixed bearing below, and can be pushed or pulled backwards and forwards from above. The bob once set going is its own crank and fly-wheel. A sudden push given to the axle crosses the bob in the same direction, and the axis being then held till the bob by its inertia has attained the other side, the axis is pulled, and then the bob gets a further motion: by means of alternating the action and non-action of the axis to coincide with favourable situations of the bob, it is made to obtain a rotation, which is easily maintained by a regular to-and-fro movement of the axis, whose upper end works in a gimbal, and is guided in its motions by a groove.

YATES (No. 378) exhibits an instrument for squaring the circle. Its principle is, that the diameter of a circle, multiplied by 1·25, equals the diagonal of the square required.

ROBERTS (No. 130) has exhibited a synchronometer. It consists of a gutta-percha tube, connecting two expansions, of the nature of bellows, of vulcanized India-rubber: on expanding one of these by a spring worked by an excentric wheel in connection with any movement, a partial vacuum is created, which being propagated along the tube, sucks in and closes down the other, whose movement puts in action a click acting on a ratchet-wheel. Thus every movement of the mechanism at one end of the tube may be synchronously (or very nearly so) communicated to a corresponding mechanism (as a clock) at the other.

COOKE (No. 664A) exhibits closed cases for plants.

BATEMAN (No. 187) exhibits a machine intended to illustrate the effects of centrifugal force. It consists of a representation of the planet Saturn, attached to a piece of string by the edge of its ring, which, when in a state of repose, is in the same straight line with it, but on a rapid twisting motion being communicated to the string by clockwork, the object occupies a position at right angles to the string, or, in other words, spins round upon its shorter axis.*

Darnell (No. 383) exhibits an apparatus for the detection of either fire or robbery; consisting of a lever, with a centre-tumbler and balance-weight, which is poised by a small line carried through any portion of a house, and fastened. On the least pressure the balance-weight is raised; or if the line be cut or burnt, it will fall into a notch: in either of which cases, the alarum is put in motion. It is contained in a small portable box.

Saunders (No. 205) exhibits a kaleidoscope which revolves on pressing the covering of the eye-piece downwards, and, therefore, is self-acting whilst the instrument is in use. This is the only kaleidoscope exhibited.

Knight and Sons (No. 453) exhibit a machine for cleaning and polishing daguerreotype plates; portable mercury box; plate-holders; head-rests, with a series of bolt-and-socket joints; glass and porcelain dishes for preparing sensitive paper.

Thomson (No. 80) exhibits an instrument called an autochronograph, intended for the registration of the times of occurrences; for example, to register the time of the arrival and departure of trains in railway stations, &c.—to note the presence and individuality of guards, and other persons whose absence might incur inconvenience or danger: it is thus of use also in police and public offices, banking and mercantile houses, &c.

Dyer (No. 370) exhibits a circular slate, divided into as many equal portions as there are days in the month. It is intended to make memoranda of engagements, &c., that occur on each day; and when properly adjusted at the end of each month, and turned day by day, each day's engagements are brought correctly under notice.

Roper (No. 197) contributes Lawson's observing chair, to enable astronomers to observe with large telescopes.

Watkins and Hill (No. 659) exhibit Biot's apparatus for the polarization of liquids; a reflecting polariscope; an oxyhydrogen polariscope; Attwood's machine; and a steam-engine indicator, for ascertaining the power of steam-engines.

Newberry (No. 460) has exhibited a case of medals, the metal precipitated by electro-metallurgy, containing—a medal of Alfred the Great; Clement XII., from a very scarce original; Pius V., from the original in the possession of the exhibitor; and various others.

Rundell (No. 438 a) exhibits impressions of seals, the depth and execution of which are very good, as are the ciphers and arms, particularly when it is considered that they have been executed by machinery.

Willatts (No. 205) has exhibited a registering thread-counter, or linen-prover; a small instrument designed for the purpose of ascertaining the number of threads in a certain-sized piece of linen or silk, by means of an index and a self-registering apparatus. A magnifying lens is also attached, for examining the texture of the material to be tested.

Haward (No. 298) has exhibited a gauge for measuring the thickness, and

* See Dr. Parr's Philosophy of Motion for a distinct description of this machine.

ascertaining the weight of metal and other plates, rods, and bars. Its principle is the progressive movement of a most accurately-cut screw, to which is affixed a dial or circular index, so divided that each space indicates the advance of the screw to the thousandth part of an inch. The gauge exhibited is so divided that each of the smaller divisions represents 1 ounce per foot of superficial sheet iron, whose specific gravity is 7·68, with other divisions, till a weight of 20 lbs. to the square foot is shown. This gauge is convenient in use, and Mr. Haward has very wisely adopted the decimal notation in the subdivision.

Edge (No. 702) exhibits a photometer for the determination of the illuminating power of gas, as compared with that derived from any other source. The instrument was not tried by the Jury.

Chamberlain (No. 399) exhibits a large model of a machine for recording votes, and is so constructed that the vote shall be recorded without the manner of its disposition being made known, the number of votes given, being indicated by the sounding of a bell. The machine appears to be well adapted to the purpose intended, and combines ingenuity of construction with careful workmanship. Being an instrument intended for direct use, it does not fall within the province of this Jury, and was not subject to an award in Class X. This notice is given in consequence of its being placed among philosophical instruments.

Baker (No. 396) has exhibited a vacuum gauge, furnished with a sliding scale, the glass tube being protected by a bronze covering. Also a vacuum gauge, fitted in a brass case, showing a scale of more than 22 inches, and is intended for sugar-boiling, and for situations where space is an object. A steam-gauge, upon the principle of compressed air, to show the temperature of steam at various pressures. Another steam-gauge, so constructed as to be less easily deranged by carriage from place to place.

Brown (No. 335) has exhibited a patent power engine, which acts as a water-meter. Its novelty consists in its economy of space: it is 3 feet in height, 2 in length, and 2 in width. He also exhibits a patent water-meter, which is 2 feet in length, 2 in width, and 1 foot 6 inches in length; stated to keep perfect adjustment under varying pressure. Also a patent water-meter, stated to work in compressed air, without cock or valve; and two other meters. (See the Illustrated Catalogue.)

Lawrence (No. 115) exhibits a screw-wrench, capable of being adjusted by a spring, and of being varied in size in a moment. Also a pair of dividers; a hand-drill, intended to supersede the use of the bow-drill, and driven by a crank. A turner's centre-bearing, with friction-rollers to prevent small articles from moving in the lathe, and to enable the lathe to turn easier than in the ordinary way. These articles all seem to be useful, but scarcely belong to Class X.

Plant (No. 215) has exhibited a self-registering steam-boiler feeding apparatus, intended as a substitute for the common force-pump and regulating-float.

Rocher (France, No. 991). A tank apparatus, for the distillation of water; adapted to the use of a ship of the line. The workmanship is excellent, but it can, in no respect, be considered a philosophical apparatus.

Green (No. 446) has exhibited damp detectors, fitted up in different kinds of boxes; also several angle meters.

Merryweather (No. 151) has exhibited a tempest prognosticator. This consists of a number of bottles placed on an ornamental stand, in each of which it is proposed to place a leech, so as to render available the well-known sensitiveness of this animal to changes of the weather.

Before closing this Report, it may be well to dwell for a short time upon the probable good resulting from the exhibition of the subjects which it embraces. So vast is the field over which it is spread, and limited the time allowed for its preparation, that, in some instances, we have been able only to enumerate, without fully discussing, the merits of individual works. No opportunity, for the same reason, is afforded, of instituting an inquiry into the comparative importance of the several classes of instruments—an inquiry which would be attended with great labour, from the necessity of gravely weighing and determining the comparative value of results which we have been enabled simply to record.

That the Exhibition will form an era in art and science is to be expected; and that both will benefit greatly from so large a collection of instruments and useful applications from all countries is also certain. That it is not calculated to engender national animosities will be seen by a review of our Report, which discovers the fact, no less pleasing than anticipated, that every country is characterized by peculiar excellence in some department; and we might venture to predict, that steady and constantly progressive as the advancement of science has been—from the broad basis now offered for the first time, as a groundwork for future improvements—it will receive a fresh impulse and many accessions from new and otherwise unexpected quarters. That the Exhibition has received contributions from individuals of various grades, is one of its most pleasing features, as is the fact that a vast field for increase of knowledge, and a means of self-education, has for the first time been opened to the artizan. This class of individuals greatly want a knowledge of that which has been done—a deficiency the Exhibition is well calculated to supply, and may thus divert much fruitless labour and ingenuity into newer and more useful channels. That there does exist in this class of the community a considerable amount of ability and power of application, is evidenced by the various patents which have been taken out for ideas and inventions, the purchase-money of which has too often been the sole remuneration of the inventors.

The Exhibition will make the improvements which have been made in different instruments by various countries known to all, and the means for the acquisition of knowledge hitherto confined to the few, will, by it, be placed within the grasp of the many.

Glancing once more at the collection now before us, combining as it does a concentration of the labours of eminent men, who have toiled during successive generations for the advancement of science, and whose successful efforts have developed the important principles which have served for the groundwork of modern discoveries, and their beautiful applications to the wants of the present day, we are impressed more strongly than ever, with the all-important fact, that much as man has done, both in the physical and scientific world, by a long train of brilliant discoveries, there is more yet left to achieve than has hitherto been accomplished.

As heat, light, electricity, magnetism, chemical affinity, &c., by the recent discoveries of Volta, Faraday, Oersted, Seebeck, Wheatstone, &c., have been found to be mutually related, so that heat may be said to produce electricity, and *vice versâ*, and so on for all the rest, we may expect that a still more intimate union than that already discovered may be found to exist. That things apparently distinct and remote prove to be linked together and inseparable, is instanced by the frequent discovery of intermediate missing links in the continuity of the chain connecting all living bodies from the most minute, and almost inanimate, to man, and which have tended to prove that the powers with which they are severally endowed, and the principles of their formation, have been regulated upon one grand system of gradation, having unity alone for its summit. That the effect of a concentration of the sciences of the age must be infinitely greater than that exerted by a single one is obvious; as also that this concentration and union, once effected, will be productive of vast and universal applications, such as we dare not even to predict.

The Exhibition, by collecting, within a comparatively small space, almost all the known applications of science throughout the civilized world, is eminently qualified for the attainment of this great end, by promoting the advance of science in its various branches, and by infusing a taste for the development of the highest faculties with which man is endowed.

JAMES GLAISHER, *Reporter*.

Lewisham, Nov. 1851.

INDEX TO CLASS X.

Note.—This Report being so extensive, and embracing a large variety of subjects, it has been deemed by the Author expedient to prepare a special Index to accompany it.

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